# “EFFECT OF GAMMA IRRADIATION ON MORPHOLOGICAL CHARACTERS OF MARIGOLD (*Tagetes erecta* L.)”


***By***

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**RAHURI-413722, DIST. AHMEDNAGAR**

**MAHARASHTRA STATE (INDIA)**


**2015**

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prevailing in the universe

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A thesis submitted to the

**MAHATMA PHULE KRISHI VIDYAPEETH**

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**MAHARASHTRA STATE (INDIA)**

By

**Mr. BHUSARI ARJUN VISHNUKANT**
**B.Sc. (Agri)**

In partial fulfilment of the requirement for the degree of

**MASTER OF SCIENCE (HORTICULTURE)**

In

**FLORICULTURE AND LANDSCAPING**

**DEPARTMENT OF HORTICULTURE**

**COLLEGE OF AGRICULTURE**

**PUNE – 411005**

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Approved by

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**2015**

## CANDIDATE'S DECLARATION

I hereby declare that, this thesis entitled, **"EFFECT OF GAMMA IRRADIATION ON MORPHOLOGICAL CHARACTERS OF MARIGOLD (*Tagetes erecta* L.)"** or part there of has not been submitted by me or any other person to any other University or Institute for a Degree or Diploma.

**Place:** College of Agriculture, Pune

**Date:** / / 2015 **(BHUSARI A. V.)**

**Dr. M. R. DESHMUKH**
Chairman and Research Guide
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## CERTIFICATE

This is to certify that the thesis entitled**, "EFFECT OF GAMMA IRRADIATION ON MORPHOLOGICAL CHARACTERS OF MARIGOLD (*Tagetes erecta* L.)"** submitted to Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar, Maharashtra in partial fulfilment of the requirement for the degree of **MASTER OF SCIENCE (HORTICULTURE) in Floriculture and Landscaping,** embodies the results of a piece of bona-fide research work carried out by **Mr. BHUSARI ARJUN VISHNUKANT**, under my guidance and supervision and that no part of the thesis has been submitted for any other Degree or Diploma.

The assistance and help rendered during the course of this investigation have been duly acknowledged.

**Place:** Pune
**Date:** / / 2015

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## CERTIFICATE

This is to certify that the thesis entitled, **"EFFECT OF GAMMA IRRADIATION ON MORPHOLOGICAL CHARACTERS OF MARIGOLD (*Tagetes erecta* L.)"** submitted to the Faculty of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar, Maharashtra in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (HORTICULTURE) in FLORICULTURE AND LANDSCAPING,** embodies the results of a piece of bona-fide research work carried out by **Mr. BHUSARI ARJUN VISHNUKANT,** under the guidance and supervision of **Dr. M. R. DESHMUKH,** Assistant Professor of Horticulture, College of Agriculture, Pune and that no part of the thesis has been submitted for any other Degree or Diploma.

**Place :** Pune
**Date :** / / 2015

**(D. W. THAWAL)**
Associate Dean

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***Place: Pune.***

***Date: / /2015*** **(Bhusari Arjun Vishnukant)**

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## ABBREVIATIONS

| | | |
|---|---|---|
| @ | : | at the rate of |
| % | : | Percent |
| / | : | Per |
| + | : | Plus |
| $^0$C | : | Celcius |
| C.D. | : | Critical difference |
| cm | : | Centimeter |
| cv. | : | Cultivar |
| *et al.* | : | et al (and others) |
| etc | : | Et cetera |
| Fig. | : | Figure |
| g | : | Gram(s) |
| Gy | : | Grays |
| i.e. | : | That is |
| Kg | : | Kilogram |
| Kr | : | Kilorad |
| m | : | Meter |
| No. | : | Number |
| Spp | : | Species |
| Sr. No | : | Serial Number |
| S.Em (±) | : | Standard error of mean |
| viz. | : | Namely |

# ABSTRACT

# ABSTRACT

**"EFFECT OF GAMMA IRRADIATION ON MORPHOLOGICAL CHARACTERS OF MARIGOLD (*Tagetes erecta* L.)"**

**By**

**MR. BHUSARI ARJUN VISHNUKANT**
**(Reg. No. 12/332)**
A candidate for the degree
of
**MASTER OF SCIENCE (HORTICULTURE)**
**In**

**FLORICULTURE AND LANDSCAPING**

**2015**

**Research Guide : Dr. M. R. DESHMUKH**

**Department : Horticulture**

The present investigation on "Effect of gamma irradiation on morphological characters of marigold (*Tagetes erectca* L.)" was undertaken during 2013-14 at Modibaug, College of Agriculture, Pune- 411005. The experiment was laid out in randomized block design with seven treatments and three replications.

The seeds of African marigold cv. Pusa Narangi Gainda were treated with different gamma irradiation treatments *viz.* control ($T_1$), 25 Gy ($T_2$), 50 Gy ($T_3$), 75 Gy ($T_4$), 100 Gy ($T_5$), 125 Gy ($T_6$) and 150 Gy ($T_7$) and evaluated for various morphological characters.

The observations recorded on plant height, number of branches per plant, plant spread, days required for first flower bud initiation, days required for flower opening, diameter of flower, length of peduncle and number of flowers per plant were significantly influenced by gamma irradiation and their different doses. The results on survival percentage, petal colour and flower form were not found significant.

Out of various doses of gamma irradiation, the results of treatment $T_2$ (25 Gy) was found to be promising for plant height, number of branches, plant spread, number of days required for first flower bud initiation, number of days required for flower opening, diameter of flower, number of flower per plant and length of peduncle.

It can be concluded that irradiation of gamma rays of 25 Gy was found beneficial for growth and flowering in African marigold cv. Pusa Narangi Gainda.

# INTRODUCTION

# 1. INTRODUCTION

Flowers are God given gift of the nature. It is said that Indian is born with flowers and finally dies with flowers. Flowers are associated with mankind from the dawn of civilization. They form the soul of gardens and convey message of nature to man. It is truly a symbol of affection, beauty, friendship and love. Thus it is an inseparable part of human life.

Floriculture is an important segment of Agriculture. All over the world, floriculture is experiencing rapid changes. As an effect of modern globalisation and its effect on income generation in different parts of the world, the per capita consumption of flowers in most of the countries is increasing. The international trade of cut flower is concentrated in the European Unions, Japanese and US markets. The Netherlands, Kenya, Israel, Colombia and Ecuador are the major cut flower exporting countries. Countries like Guatemala, Chile, Uganda, Tanzania, India, China, Korea and Vietnam etc. are moving in the direction of intensive floriculture.

India has a long tradition of floriculture. It is recognized as a lucrative business since it has higher potential per unit area than most of the field crops, and even horticultural crops both for domestic and export market. Flowers make the environment happy, clean and pollution free. They are also used for decoration and aesthetic purpose; they have tremendous economic value as a cut

flower, loose flower, for perfumes and other products, which play a major role in uplifting our national income.

Presently in India total area under floriculture is about 2 lakh 33 thousands ha. with a production of loose flowers 1729.2 thousands MT and cut flowers 76731.9 lakh nos. (Anonymous, 2013a). In Maharashtra state total area under floriculture is 22,000 ha. with a total production of 119,000 MT (6.88%) loose flower and 7914.0 lakh nos.(10.3%) of cut flowers (Anonymous, 2013a). In India the marigold flowers of various colours are being grown for loose flowers in 42,880 ha. of land producing around 360.21 thousands MT every year. India has exported 27,121.88 MT of floriculture products to the world (Anonymous, 2013b).

Availability of varied and favourable agro-climatic conditions, cheap and ample labour, required knowledge base, vast research network and traditional places in India are advantageous positions to produce flower year round. Among the commonly grown flowers in India the most important ones are marigold, aster, chrysanthemum, rose, carnation, jasmine, crossandra, tuberose, gladiolus, orchid, etc. which are grown commercially over large area in Tamil Nadu, Karnataka, Andhra Pradesh, West Bengal, Bihar, Rajasthan, Delhi, Uttar Pradesh and Maharashtra.

The major production is located in southern part of India *viz.*, Bangalore, Hyderabad, Chennai, some of the areas of Delhi and Gurgaon. As far as Maharashtra is concerned, commercial cultivation of flower crops is predominant in Western Maharashtra. Maharashtra

occupies an important place in floriculture industry. It is perhaps the only state which took initiative in developing and promoting floriculture at state level. Floriculture in Maharashtra is mainly concentrated in the districts of Nashik, Ahmednagar, Pune, Satara, Sangli and Kolhapur. Pune has emerged as a centre for production and marketing of flower crops. Favourable climate throughout the year is most congenial factor for floriculture hub in Pune city. The productivity of marigold in Maharashtra is about 10 MT per hectare and production is about 65,000 MT in 7000 ha. Area (Anonymous, 2013a).

Among the leading loose flowers, marigold (*Tagetes erecta* L.) is one of the important popular commercial flowers widely grown throughout the world. It belongs to family Compositae and genus Tagetes. The genus Tagetes comprises of about 33 species of which *Tagetes erecta* (African marigold) and *Tagetes patula* (French marigold) are under commercial cultivation in India. It is a seasonal flower crop cultivated for its loose flowers. Origin of marigold is Central and South America, especially Mexico (Kaplan, 1960). The chromosome number is x=12 and 2n=24. The other species introduced in India are *Tagetes signata Linn., Tagetes minuta Linn., Tagetes lucida and Tagetes tenufolia.* Marigold has its own importance and is called as 'Poor man's crop'. It is universally a popular seasonal flower grown as an ornamental, loose or cut flower, bedding, pot or landscape plant, easy to cultivate with worldwide adaptability to varying soil and climatic conditions. Marigold

with its bright colours ranging from yellow to orange is the best for combination in any colour scheme. The attractive and brilliantly coloured flowers are the most valuable economic part of the plant, used for garland making, religious offerings, exhibitions, decorations, etc. Apart from this, 'Thiopenes', a chemical compound extracted from the leaves of marigold is used as mosquito repellent. The whole plant is a source of an essential oil used in perfume industry; the roots of *Tagetes spp.* secrete an alkaloid which has strong nematicidal property (Bose and Yadav, 1989).

Marigold is commonly used for the extraction of 'Xanthophyll' pigments which are used to intensify the yellow colour of egg yolks and broiler skin; it is also a potential source of emulsifying gum (Singh *et al.,* 2004). Wild marigold (*T. minuta*) is considered as the best source of valuable essential oil among the other species of this genus (Singh *et al.,* 2002). Marigold plants are grown for pigment production in Mexico, Peru and India (Bose *et al.,* 2002).

Marigold is extensively used on religious and social function in different forms. It was introduced by Portuguese in India during 16$^{th}$ century and since then it has been naturalized in different agro-climatic regions of India in such a way that it has now appeared to be native of this country. It has gained popularity amongst gardeners and flower dealers on account of its easy culture and wide acceptability. It requires short day condition to produce marketable flower, wide spectrum of attractive colour, shape size and good keeping quality. The attention of producers

and traders is mostly towards the commercial cultivation of this crop in the vicinity of different cities and towns. Flowers are sold in the market as loose flowers or in the form of garlands. Due to its variable colour and height marigold is especially used for decorations included in landscape plants.

In Maharashtra state marigold is cultivated on commercial scale as loose flower in Ahmednagar, Pune and Thane districts. However, still it has not been able to boost the cultivable area and the production of flowers, for the exploitation of this huge potential for consumption and trade. We have to concentrate on the quality as well as quantity of production. The people of Pune celebrate the festival such as 'Ganesh-utsav', 'Dashera' and 'Diwali' on a large scale. During these festivals marigold flowers are highly preferred for their aesthetic value. Hence it has got premium potential market in the region. The biggest snag in India is the non-availability of genuine and good quality planting material.

The major problem in its cultivation is lack of standard varieties and standard package of practices, keeping this in view so many private companies and ICAR, New Delhi through various research stations under took the breeding work in marigold and released promising hybrids for the growers. These hybrids have premium quality flowers, dwarf plant height, greater yield, large sized flowers, attractive colours and shape of the flowers, potential resistance to various pests and diseases. Therefore it has now become imperative to concentrate on research and development to

develop our own and new genotypes by making a change in the genetic makeup of existing cultivars, to make the technology cheap and cost effective. Conventional breeding is a time consuming process for genetic improvement of the floricultural crops. In marigold, it is very difficult to maintain the parents in pure form and to make the male sterile line by using conventional breeding methods. Mutation breeding is also an efficient way to produce heritable changes particularly for flower colours. Genetic variation is essential in any plant breeding programme for crop improvement. Induced mutations are highly effective to enhance natural genetic resources. (Jain, 2006). Therefore the present investigation on studies on the effect of gamma irradiation on morphological characters of African marigold was planned and conducted at Modibaug, College of Agriculture, Pune with the following objective:

1) To explore the possibilities of physical mutagens to create variability in marigold.
2) To study the morphological changes in African marigold as a result of mutagenesis.

# REVIEW OF LITERATURE

## 2. REVIEW OF LITERATURE

Mutation is a sudden heritable change in the characteristic of the genetic makeup of a plant. Mutation can be induced with relatively higher frequencies by treating the plant material with certain mutagens. Spontaneous and induced mutations have played an important role in the evolution of many important cultivars of African marigold.

The essentiality of mutation breeding was proved long before their role in crop production was recognised. The research work regarding mutation breeding in flower crops is meagre in India and there are a few reports on effect of gamma irradiation on flower crops. However work on chrysanthemum, gladiolus and bougainvillea has been reported. The literature pertaining to mutation breeding in marigold is obscure and as such the literatures pertaining to mutation breeding in other crops have been reviewed here under.

Sagwa and Mehlquist (1957) studied the effects of 2.5 to 5.0 KR X-rays on three Sim carnation cultivars (Pink Sim, White Sim and William Sim). An extremely high number of changes in colour (47-91%) from pink to red were observed.

Buittai and Ragazzini (1964) carried out research on the induction of somatic mutation in carnation by gamma rays. Decrease in number of branches and flowers per plant were observed. Four types of induced colour changes were recorded in one variety (Elia Rosso) and one in the other (Cardinal Sim).

Broertjes (1966) irradiated rooted cuttings of the pot-grown chrysanthemum variety “Hortensien Rose” with X-rays (1500-2000 Rad), fast neutrons, thermal neutrons and electrons. Electron proved to be ineffective, producing only 6-10% mutated plants. Fast and thermal neutron showed a marked higher mutation frequency. The optimum dose of X-rays was found 1500 Rads.

Dowrick and Bayoumi (1966) irradiated plants of the *Chrysanthemum* variety ‘New Princess’ with 500-2000r X-rays and 1-4 Krad gamma rays. Flower colour changes were induced by both types of radiations and optimum doses were 1000r X-rays and 1 Krad gamma rays. The frequency of mutation was directly proportional to the dose.

Broertjes and Ballego (1967) studied mutation breeding of *Dahlia variabilis*. Tubers of garden dahlia cultivars were irradiated with the optimal dose ranging 2-3 Krad of X-rays considering the production of rooted cutting and the subsequent development of young plants. Four mutants of “Salmon Rays” variety were awarded, named, registered as new varieties and put on the market.

Samata *et at.* (1979) studied effect of gamma irradiation on 30 carnation cultivars. Gamma irradiation causes 3.3 to 30% colour change in various directions, frequently from recessive to dominant colour. In one cultivar having colour of petals clear pink the anthocyanidin changes from cyanidin to pelargonidin and this was the only instance considered to be caused by gene mutation.

Wosinska (1982) studied the effect of irradiation (3-12 Krad) in the $M_1$ generation and in the $M_2$ generation of five cultivars of china aster. Changes induced by irradiation *viz.* height of the plants, colour of shoots, leaves and flowers were more frequent in the $M_2$ than in the $M_1$ generation.

Misra and Bajpai (1983) carried out mutational studies in gladiolus on effect of physiological and chemical mutagens on sprouting and survival of corms. It was observed that sprouting enhanced in Blue Lilac and delayed in Sans-Souci and Murielae whereas in other varieties of gladiolus LD-50 for survival lies between 7 to 10 Kr gamma radiations.

Oradee-Sahavacharin and Chaichoompon-Suriyasak (1984) studied effect of gamma radiation on each shoot tip of "White Sim" carnation of about 1.5-2.0 cm, which was cultured in Murashige and Skoog media. The survival as well as growth rate were decreased with the increasing dose and the diameter of the flower and the size of leaves were not different from the control.

Datta (1986) studied the effects recurrent gamma irradiation on budwood of rose cv. Contempo. Reduction in plant height and colour change of flower petals from orange to light orange was observed. Cumulative effects were found on sprouting and survival after recurrent irradiation.

Fererro *et al.* (1987) reported that more than 35 new cultivars have been produced by petal colour mutation from the carnation cv. Londorga. Cultivars were collected and

subjected to gamma irradiation with doses of 20, 40, 60 Gy to study their histogenetic structure and observed a tendency to revert the Londorga's original morphological characters. They also observed that application of 40 and 60 Gy produced the most effective results.

Nokaido and Onosawa (1989) treated seedlings of chrysanthemum cv. Delaware with gamma irradiation of 3.5 KR dose. A new yellow flower colour mutant was obtained.

Banerji and Datta (1991) studied induction of somatic mutation in chrysanthemum cv. 'Anupam'. Rooted cuttings were irradiated with 1.5, 2.0 and 2.5 krad gamma radiation. Significant reduction in survival, plant height; branch, leaf, and flower head number and leaf size were recorded. Morphological and mitotic abnormalities were recorded. Somatic flower colour mutations were found in the $M_1$ population as chimeras and three flower mutants *viz.* paler, striped and white, were isolated and established as new cultivar.

Banerji and Datta (1992) irradiated rooted cuttings of chrysanthemum cv. 'Jaya' with 1.5, 2 and 2.5 krad doses of gamma rays and reported reduction in survival, growth, plant height, number of branches and leaves per plant, leaf and flower size with the increased morphological, floral and chromosomal abnormalities.

Ahloowalia (1992) obtained new and novel types of chrysanthemum for flower shape and size and for plant height by combining *in vitro* radiation and micropropagation.

He suggested this technique as a rapid and efficient method for obtaining new cultivars of vegetatively propagated plants.

Datta and Banerji (1993) used rooted cuttings of small decorative type chrysanthemum cv. Kalyani Mauve which were irradiated with 150, 200 and 250 Gy of gamma rays. Reduction in survival, plant height, branch, leaf and flower head number and leaf size and increased chromosomal aberration, foliage and floral abnormalities along with delayed flowering behaviour were observed after irradiation. Somatic mutation in flower colour and shape were detected as chimera in all doses. Four flower colour and one changed flower shape mutants were isolated and established in pure form.

Shukla and Datta (1993) studied the mutation on an early and three late varieties of garden chrysanthemum which were treated with 1.5, 2.0 and 2.5 krad of gamma rays. Reduction in plant height, number of leaves and number of branches along with various abnormalities in leaves and flowers were recorded. They found somatic mutations in flower colour in all the varieties after irradiation.

Janakiram and Rao (1995) treated seeds of three varieties and one pure line of China aster with gamma rays at 10, 20 and 30 Krad dosages. Lower doses of gamma rays showed stimulatory effect and higher doses showed inhibitory effects with respect to seed germination

percentage. The seedling height and spread were reduced as the dosage increased.

Banerji *et al.* (1996) studied the effect of gamma rays at 1.5, 2.0, 2.5, 4, 6 and 8 KR on stem cuttings of rose cv. Grussantepliz and rooted cuttings of chrysanthemum cv. Navneet. Sprouting and growth were stimulated in cv. Grussantepliz up to 10 months. Reduction in survival, plant height; leaf, flower, floret number, pollen fertility and increased foliage, floral and stomatal abnormalities were observed after irradiation.

Jerzy and Zalewska (1997) observed that mutants of chrysanthemum and gerbera exhibiting changed inflorescence colour after irradiation of leaf explants and regeneration from adventitious roots.

Venkatachalam and Jayabalan (1997) induced mutation in *Zinnia elegans* Jacq. cv. Crimson Red by using gamma irradiation for plant morphology and flower colour. Significant effects were observed as increased mean value of plant height, branch number, flower number and flower diameter upto 7.5 kR. 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 observed *viz.* majenta, yellow, red and red with white.

Singh *et al.* (1999) studied *in vitro* effects of 5, 10, 20, 30, 40 and 50 Gy gamma rays in carnation cv. Espana. Overall effects on vegetative and floral characters increased

with increase in treatment dose. Irradiation with 30 Gy and above induced flower colour variation. Dark pink mutants were observed with 50 Gy treatments at a frequency of 4.44%. Dark pink mutants with red patches were produced by treatment with 30 and 40 Gy doses at frequencies of 1.79 and 3.94 per cent respectively.

Dwivedi *et al.* (2000) treated the rooted cuttings of chrysanthemum cv. 'Lilith' with 1.0, 1.5 and 2.0 krad of gamma rays. Plant height, leaf size, flower size, petal size and flower per plant were reduced after gamma irradiation and the reduction in higher dose was found significant. Different types of morphological abnormalities were recorded in leaf and flower.

Jerzy and Zalewska (2000) studied effect of X and gamma rays on *in vitro* adventitious bud production of pot carnation (*Dianthus gratianopolitanus* Vill.) by exposing internodal segments of pot cv. Mini Pinky to ionizing radiations X- and gamma rays in the range of 5-30 Gy. Dose 30 Gy of X-rays completely reduced the regeneration ability of internodal segments.

Siranut Lamseejan *et al.* (2000) studied the effect of gamma radiation on *in vitro* culture of chrysanthemum (*Chrysanthemum morifolium*). At 0, 10, 30, 50, 70, 90 and 110 Gy dose of gamma rays shoots were irradiated, only control and plants treated with 10 Gy were observed to survive and developed into mature plants.

Ahloowalia and Maluszynki (2001) reported that the use of ionising radiation such as X-rays, gamma rays and neutrons for inducing variation is well established. Many mutants that change floral development were isolated in *Arabidopsis, Petunia, Chrysanthemum, Alstromeria, Antirrhinum* and carnation.

Banerji and Datta (2002) irradiated rooted cuttings of chrysanthemum cv. 'Lalima' with 0, 15, 20 and 25 Gy of gamma rays. Reduction in survival, growth, number of branches and leaves per plant, leaves and flower size and increased morphological and floral abnormalities were recorded. Significant reduction in plant height, flower head diameter was recorded. Gamma ray induced flower head shape mutant of cv. Lalima was very attractive and ideal for pot culture.

Datta (2002) indicated that nuclear radiation (gamma rays) can create changes in genetic makeup of plant material through mutation. Gamma rays have been successfully used to produce a large number of new promising varieties in different floricultural crops. A good number of mutant varieties were accepted in the floriculture industry.

Shrivastava *et al.* (2002) irradiated stem cuttings of 20 cultivars of bougainvillea belonging to different group, bract colour and type with 500 and 750 rad and 1.0, 1.25, 1.75 and 2.25 krad of gamma rays. Reduction in sprouting, plant height and survival were recorded after irradiation in most

of the cultivars. Stimulation in all these characters was also recorded in some cultivars at lower doses.

Dilta *et al.* (2003) studied effect of gamma rays on vegetative and flowering parameters of chrysanthemum. The rooted cuttings of ten chrysanthemum cultivars were exposed to gamma rays treatments (0 and 2.0 Krad). The significant reduction in plant survival, plant height, growth, number of branches, leaf size, number of leaves and flowers with the increased floral and foliage abnormalities were found.

Kole and Meher (2005) studied effect of gamma rays of some quantitative and qualitative characters in *Zinnia elegans* in $M_1$ generation. Dry seeds of two varieties of zinnia were irradiated with 5, 10 and 15 kR doses of gamma rays. Plant height, number of branches, pedicel length and flower diameter increased at lower doses of 5 kR followed by decrease at higher doses of 10 kR onwards as compared to non irradiated control. Survival at maturity was decreased with increasing doses of gamma rays.

Paramesh and Chowdhury (2005) carried out irradiation on *in vitro* shootlets of carnation (cv. IIHRS-1) with gamma dosage of 20, 40, 60 and 80 Gy. The results indicated gamma-radiation at 40 Gy to be the ideal dose for mutagenesis was used in combination with regeneration. Survival percentage decreased with increased dosage of gamma radiation.

Jain (2006) carried out study on mutation assisted breeding for improving ornamental plants and stated that among mutagens, gamma rays have been commonly used efficiently in mutation induction in chrysanthemum, orchid, canna and carnation. Also suggested that mutation-assisted breeding (MAB) together with biotechnology can contribute greatly for genetic improvement of ornamental plants and in up lifting the socio economic benefits in the developing country.

Song-Hisup *et al.* (2006) developed new 'Changhae' variety of hibiscus by mutation breeding using 100 Gy gamma rays from a cobalt $CO_{60}$ (cobalt sixty) source. They observed that the leaf traits and size of flower of new variety were larger than original variety, except for the incision depth and base angle of the leaf.

Boersen *et al.* (2007) studied the effect of various rates of gamma radiation on non rooted cuttings of chrysanthemum cv. 'Cherry Dark'. The gamma radiation rates were 0.0, 10.0, 12.5, 15.0, 17.5, 20.0, 25.0 and 30.0 Gy. Tendency of linear decrease in plant height and quadratic tendency in survival percentage was observed with increased doses of mutagen.

Kang *et al.* (2008) carried out study on recent trends on crop genetic improvement using mutation techniques and observed that sources of X- rays and gamma rays have been most frequently used for induction of mutations with

radiation for the development of potential varieties of flowering and ornamental crops.

Yamaguchi *et al.* (2008) irradiated *Chrysanthemum morifolium* cv. 'Tahei' plants grown by *in vitro* culture with 15, 30 and 60 Gy gamma rays at a rate of 0.5, 1, 2 and 5 Gy/h. The regeneration rate decreased with increase in the total dose and dose rate of irradiation. They concluded that gamma ray irradiations of high total doses at low dose rates efficiently induce mutations with less radiation damage in chrysanthemum.

Misra *et al.* (2009) studied the effect of gamma irradiation on chrysanthemum cv. 'Pooja' with particular reference to induction of somatic mutation in flower with 0, 10, 20 and 25 Grays of gamma rays. The number of branches, leaves and flower head per plant, plant spread and size of leaves decreased after irradiation with increase in exposure to gamma rays. The frequency of leaf abnormalities increased with increase in exposure to gamma rays.

Singh *et al.* (2009) studied the effect of irradiation on 'Pusa Narangi Gainda' with different doses *i.e.* 0,100, 200, 300, 400 Grays for induction mutation. The effects seen were reduction in survival percentage, plant height, number of branches, leaf number, plant spread, size of leaves, and diameter of stem, increased foliage and floral abnormalities in higher doses of gamma irradiation. Flower-head size,

height and weight were highest at lowest dose. Exposure to 100 Grays resulted in higher yield and marketable bloom.

Mahure *et al.* (2010) irradiated unrooted cuttings of chrysanthemum cv. Red Gold with 10, 20 and 30 Gy gamma rays and stated that lower doses of gamma irradiation resulted in hormesis and induced encouraging novelties while the higher doses often induced high degree of abnormalities and consequent mortality. Delayed flowering and significant reduction in number of flowers and flower diameter was observed with increasing rate of gamma irradiation.

Tiwari and Kumar (2011) carried out three years mutagenesis programmes on pot marigold (*Calendula officinalis*) using the dose of 2.5, 5 and 7.5 KRD of physical mutagens (gamma rays). Reduction in survival rate, days to flower, fresh weight was observed with increase in exposure of gamma rays. Significant increase in plant height at 2.5 KRD and stunted growth at 5 KRD gamma irradiation was observed. They found the intensity of inhibition increased with increasing exposure while lower exposure was stimulatory and concluded that 2.5 KRD dose of gamma rays are suitable for induction of somatic mutation in calendula.

Kumari *et al.* (2013) treated rooted cuttings of chrysanthemum variety 'Otome Pink' with 0, 10, 15 and 20 Gy of gamma rays. Reduction in plant survival, plant height, number of flower heads, stems per plant, stem diameter and

leaves per plant was observed after gamma irradiation. Delayed flowering and plant in vegetative stage were observed at 20 Gy and various changes in flower colour and shape in the form of chimeras were also recorded after treatment.

Kapoor *et al.* (2014) conducted a investigation to study hormesis, morphological and biochemical attributes associated with mutation in corn marigold (*Glebionsis segetum*) by irradiating the seeds with gamma rays at the dose of 20, 40, 60, 80 and 100 Gy. Low doses of gamma irradiation resulted in hormesis and induced encouraging novelties, while the higher doses induced higher degree of abnormalities which led to mortality.

# MATERIAL AND METHODS

# 3. MATERIALS AND METHODS

A study on "Effect of gamma irradiation on morphological characters of marigold (*Tagetes erecta* L.)" was conducted at Horticulture section, College of Agriculture, Pune-5 during the *kharif* season of 2013. During the course of investigation the material used and methods followed are as follows.

## 3.1 Details of experimental material

### 3.1.1 Location

Geographically, Pune is situated at 18°32' North latitude and 73°51' East longitude at 557.74 meters above sea level on Deccan plateau at the confluence of Mula and Mutha rivers. It is the second largest city of Maharashtra and is considered the state's cultural capital.

### 3.1.2 Experimental site

The experiment was laid out at the Modibaug garden of Horticulture section, College of Agriculture, Pune-5. The experimental plot was fairly uniform and well levelled.

### 3.1.3 Soil characteristics

The soil in the plot was medium black with good drainage and aeration.

### 3.1.4 Climate and weather condition:

The maximum temperature ranges between 34$^0$C to 40$^0$C and the minimum temperature varies from 6$^0$C to 10$^0$C. The data on weather parameters were obtained from the meteorological observatory situated at the College of Agriculture, Pune-5 to get an idea about the climatic

conditions prevailing during the period of the present investigation.

### 3.1.5 Planting Material

Marigold cultivar "Pusa Narangi Gainda" was selected for the study. The seeds of this cultivar were procured from A.I.C.R.P. on Floriculture, Ganeshkhind, Pune.

## 3.2 Method

The seeds were treated with gamma rays at Nuclear Agriculture and Biotechnology Division, Bhabha Atomic Research Centre, Trombay, Mumbai. The seeds were treated with different levels gamma rays having strength of 25Gy, 50Gy, 75Gy, 100Gy, 125Gy, 150Gy. Treatment plot size was 5.06 $m^2$ while total experimental area was 122.06 $m^2$. The spacing of 45 cm X 45 cm was maintained among the experimental plots. The details of the experiment and treatment are given below.

### 3.2.1 Experimental details

The details of the experiment are given below:

**3.2.2 Design of the experiment :** Randomized Block Design

**3.2.3 No. of replications** **:** Three

**3.2.4 No. of treatments** **:** Seven (1 Control +6 Doses of Gamma irradiation)

### 3.2.5 Treatment details: (Table No. 1)

Seven treatments were tried on one variety with six doses of gamma rays and one control (without treatment).

**Table 1: Treatment Details**

| Treatment No. | Strength of gamma rays |
|---|---|
| $T_1$ | Control |
| $T_2$ | 25 Gy |
| $T_3$ | 50 Gy |
| $T_4$ | 75 Gy |
| $T_5$ | 100 Gy |
| $T_6$ | 125 Gy |
| $T_7$ | 150 Gy |

### 3.2.6 Nursery operations

The land was prepared by ploughing, harrowing and clod crushing *etc.* to a fine tilth. Seedlings of treated seeds were raised on raised beds and then used as experimental material. Five weeks old seedlings were transplanted at 45cm X 45cm distance on ridges and furrows. Healthy seedlings with uniform growth were used for transplanting. The fertilizers at the rate of 100 kg N is in the from Urea, 50 kg $P_2O_5$ in the form of Single Super Phosphate and 50 kg $K_2O$ in the form of Muriate of Potash per hectare were applied. One third N was applied as a basal dose along with full doses of $P_2O_5$ and $K_2O$ at the time of transplanting. The remaining N was applied after four weeks of transplanting. The other cultural operations such as irrigation, weeding, spray of insecticide etc. were carried out as and when required to all the treatment plots.

### 3.2.7 Plant protection

Drenching of Bavistin (0.1%) was done 10 days after transplanting to prevent soil borne disease like *Sclerotium* rot. In later stage of growth Dithane M - 45 (0.2%) and

Bavistin (0.1 %) were sprayed alternately at an interval of 15 days to avoid the incidence of *Alternaria* leaf spot also to control attack of Hairy caterpillar spraying of Nuvan@ 1ml/lit water was undertaken.

### 3.3. Observations

Observations were recorded on randomly selected plants from each treatment for the following characters.

#### 3.3.1 Growth characters

Observation on growth characters such as survival percentage, plant height, number of branches and spread of plant (North-South and East-west) were recorded on five randomly selected plants from each plot.

##### 3.3.1.1 Survival percentage

The treated seeds were sown on raised bed to raise seedling. After transplanting the survived plant were counted according to the treatment. The survival percentage was worked out.

##### 3.3.1.2 Plant height (cm)

The height of each observational plant was recorded in centimeter (cm) with the help of measuring steel tape from the ground level up to the growing point at the time of harvesting. The mean height of the plant was calculated from the same.

##### 3.3.1.3 Number of branches per plant

The number of primary branches produced per plant was counted at the time of flowering. The mean number of branches per plant was calculated from the observations recorded for the five plants.

### 3.3.1.4 Plant spread (cm)

The plant spread of each observational plant was measured at two positions in the North-South and the East-West directions at right angles to each other at the time of flowering stretching a meter scale and expressed in centimeters (cm). The mean of these observations were taken for calculating the plant spread in the North-South and the East-West directions.

### 3.3.2 Flowering characters

To assess the effect of gamma irradiation on flowering behaviour and flower character, the observation on number of days required for emergence of flower, diameter of flower, average weight of flower, number of flowers per plant, length of peduncle, petal colour and flower form were recorded.

#### 3.3.2.1 Number of days required for first flower bud initiation

The number of days required for first flower bud initiation from the day of transplanting for each observational plant was recorded as the period required for emergence of flower bud. The mean was calculated from the data of five observational plants.

#### 3.3.2.2 Number of days required for flower opening

Five buds on the observational plants were tagged at bud emergence stage and the number of days required for the flower bud opening was recorded as the number of days required for the flower opening from the date of bud emergence. The mean number of days required for flower opening from bud emergence was calculated from same.

### 3.3.2.3 Diameter of flowers (cm)

A line joining the points at which the maximum diameter of the fully opened flower occurred was measured with the help of Vernier Caliper for ten randomly selected flowers from each plot and from this the mean diameter of flower was worked out and expressed in centimeters (cm).

### 3.3.2.4 Number of flower per plant

Total number of flowers harvested was counted separately for five observational plants. The mean number of flower per plant was worked out.

### 3.3.2.5 Length of peduncle (cm)

The length of peduncle measured with the help of measuring scale for ten flowers for each net plot and the mean was taken as length of peduncle.

### 3.3.2.6 Petal colour

The colour of the fully opened flower was recorded before they started fading by comparing their colour with colour shades in Horticulture colour chart issued by British Council in collaboration with Royal Horticulture Research Society.

### 3.3.2.7 Flower form

Petals of flowers from the experimental plot were critically observed for identifying the form of flower.

## 3.4 Statistical analysis

The statistical analysis was done by standard statistical method suggested by Panse and Sukhatme (1985). The recorded data on various observations during the course of investigation were statistically analyzed using

Randomized Block Design as suggested by Panse and Sukhatme (1985). The appropriate standard error of mean (S.Em.) and the critical difference (C.D.) were calculated at 5% level of probability. Data have been depicted by suitable graphs, figures and the appropriate tables.

# RESULTS

# 4. RESULTS

It is a well known fact that exposure of plants to gamma radiation induces various type of morphological changes. Mutagen sensitivity has been known to be influenced by variety of factors such as dosage of gamma radiations used, genotypes used and other environmental factors.

The present investigation entitled "Effect of gamma irradiation on morphological characters of marigold (*Tagetes erecta* L.)" was conducted at Modibaug, College of Agriculture, Pune-5. The observation recorded during the investigation were analysed statistically for their significance and are presented in this chapter under the following heading.

## 4.1. Growth characters

The data in respect of growth characters of plants such as survival percentage, plant height (cm), number of branches per plant and plant spread were recorded at the time of flowering and presented as under.

### 4.1.1. Survival percentage

The data pertaining to survival percentage of plants as influenced by gamma irradiation treatments are presented in Table 2 and graphically depicted in Fig. 1.

The effect of gamma irradiation treatments was non-significant with respect to survival percentage of plants. The data on survival percentage revealed that 100 per cent survival of plants was recorded under treatments control, $T_2$, $T_3$ and $T_4$. The minimum survival percentage 92 per cent was

recorded in $T_7$ (150 Gy). Ninety six per cent survival of plants was found under treatments $T_5$ and $T_6$.

**Table 2:Effect of different gamma irradiation treatments on survival percentage of marigold.**

| Sr. No. | Treatment No. | Treatments | Survival percentage |
|---|---|---|---|
| 1 | $T_1$ | Control | 100 |
| 2 | $T_2$ | 25 Gy | 100 |
| 3 | $T_3$ | 50 Gy | 100 |
| 4 | $T_4$ | 75 Gy | 100 |
| 5 | $T_5$ | 100 Gy | 96 |
| 6 | $T_6$ | 125 Gy | 96 |
| 7 | $T_7$ | 150 Gy | 92 |
| S. E. ± | | | 2.54 |
| C. D. at 5 % | | | NS |

### 4.1.2. Plant height

Plant height is very important character for growth as well as for the quality of flowers. The data pertaining to plant height at the time of flowering was analysed statistically and presented in Table 3 and graphically depicted in Fig. 2.

The results revealed that gamma irradiations had a significant influence on plant height. Maximum plant height (57.39 cm) was recorded with $T_1$ which was significantly superior over the remaining treatments except $T_2$ i.e. 25 Gy (55.68 cm) which was at par with treatment $T_1$.

**Table 3:Effect of different gamma irradiation treatments on plant height of marigold.**

| Sr. No. | Treatment No. | Treatments | Plant height (cm) |
|---|---|---|---|
| 1 | $T_1$ | Control | 57.39 |
| 2 | $T_2$ | 25 Gy | 55.68 |
| 3 | $T_3$ | 50 Gy | 54.31 |
| 4 | $T_4$ | 75 Gy | 54.06 |
| 5 | $T_5$ | 100 Gy | 53.02 |
| 6 | $T_6$ | 125 Gy | 52.62 |
| 7 | $T_7$ | 150 Gy | 52.10 |
| S. E. ± | | | 0.79 |
| C. D. at 5 % | | | 2.45 |

**Table 4:Effect of different gamma irradiation treatments on number of branches per plant of marigold.**

| Sr. No. | Treatment No. | Treatments | No. of branches per plant (No.) |
|---|---|---|---|
| 1 | $T_1$ | Control | 4.53 |
| 2 | $T_2$ | 25 Gy | 6.13 |
| 3 | $T_3$ | 50 Gy | 5.33 |
| 4 | $T_4$ | 75 Gy | 5.13 |
| 5 | $T_5$ | 100 Gy | 4.87 |
| 6 | $T_6$ | 125 Gy | 4.80 |
| 7 | $T_7$ | 150 Gy | 4.20 |
| S. E. ± | | | 0.29 |
| C. D. at 5 % | | | 0.91 |

### 4.1.3. Number of branches per plant

The data regarding influence of different gamma irradiation treatments on number of branches per plant have been presented in Table 4 and illustrated graphically in Fig.3.

Various treatments of gamma irradiation produced significant influence on the number of branches per plant.

The maximum number of branches was recorded with treatment $T_2$ (6.13) which was at par with $T_3$ (5.33). The number of branches (4.20) was found to be minimum in treatment $T_7$.

### 4.1.4. Plant spread (cm)

The output of any plant is influenced by the vigour where the plant spread plays an important role. The perusal of data presented in Table 5 and graphically depicted in Fig. 4, revealed that East-West and the North-South plant spread varied significantly with the different treatments of gamma irradiation.

The maximum East-West and North-South plant spread was recorded with the minimum dose of treatment 25 Gy i.e. 26.30 cm and 24.47 cm which was found to be at par with $T_1$ (control), $T_3$ and $T_4$ treatments respectively. The minimum East-West (20.87 cm) and North-South (18.06 cm) plant spread was recorded in treatment $T_7$.

**Table 5:Effect of different gamma irradiation treatments on plant spread of marigold.**

| Sr. No. | Treatment No. | Treatments | East-West plant spread (cm) | North-South plant spread (cm) |
|---|---|---|---|---|
| 1 | $T_1$ | Control | 25.84 | 23.25 |
| 2 | $T_2$ | 25 Gy | 26.30 | 24.47 |
| 3 | $T_3$ | 50 Gy | 24.96 | 22.58 |
| 4 | $T_4$ | 75 Gy | 23.89 | 21.78 |
| 5 | $T_5$ | 100 Gy | 23.66 | 20.89 |
| 6 | $T_6$ | 125 Gy | 22.67 | 20.04 |
| 7 | $T_7$ | 150 Gy | 20.87 | 18.06 |
| S. E. ± | | | 0.79 | 0.90 |
| C. D. at 5 % | | | 2.46 | 2.79 |

## 4.2. Flowering characters

The data in respect of flowering characters such as number of days required for first flower bud initiation, number of days for flower opening, diameter of flower, length of peduncle, number of flowers per plant, petal colour and flower form are presented below.

### 4.2.1. Number of days required for first flower bud initiation

The data regarding observation on number of days required for first flower bud initiation is presented in Table 6 and graphically illustrated in Fig. 5. From the data it could be revealed that the various treatments of gamma irradiation differed significantly in this respect.

Significantly earlier flower bud initiation was observed with the treatment $T_2$ (30.33 days) and it was at par with treatment $T_3$ (31.47 days), treatment $T_4$ (31.73 days) and treatment $T_5$ (32.33 days). The treatment $T_1$ i.e. control required maximum number of days (34.80 days) for first flower bud initiation.

### 4.2.2. Number of days required for flower opening

The number of days required for first flower opening as influenced by different treatment doses of gamma irradiation have been presented in Table 7 and graphically depicted in Fig. 6.

The treatment 25 Gy i.e. $T_2$ recorded the least number of days (10.40 days) for flower opening which was significantly superior to the remaining treatments under study except $T_1$ (10.80 days). The maximum number of days required for

flower opening was recorded with treatment of 150 Gy (12.07 days).

**Table 6:Effect of different gamma irradiation treatments on number of days required for first flower bud initiation in marigold.**

| Sr. No. | Treatment No. | Treatments | Number of days required for first flower bud initiation |
|---|---|---|---|
| 1 | $T_1$ | Control | 34.80 |
| 2 | $T_2$ | 25 Gy | 30.33 |
| 3 | $T_3$ | 50 Gy | 31.47 |
| 4 | $T_4$ | 75 Gy | 31.73 |
| 5 | $T_5$ | 100 Gy | 32.33 |
| 6 | $T_6$ | 125 Gy | 33.40 |
| 7 | $T_7$ | 150 Gy | 34.13 |
| S. E. ± | | | 0.86 |
| C. D. at 5 % | | | 2.65 |

**Table 7:Effect of different gamma irradiation treatments on number of days required for flower opening of marigold.**

| Sr. No. | Treatment No. | Treatments | Number of days required for flower opening |
|---|---|---|---|
| 1 | $T_1$ | Control | 10.80 |
| 2 | $T_2$ | 25 Gy | 10.40 |
| 3 | $T_3$ | 50 Gy | 11.00 |
| 4 | $T_4$ | 75 Gy | 11.40 |
| 5 | $T_5$ | 100 Gy | 11.47 |
| 6 | $T_6$ | 125 Gy | 11.67 |
| 7 | $T_7$ | 150 Gy | 12.07 |
| S. E. ± | | | 0.16 |
| C. D. at 5 % | | | 0.50 |

### 4.2.3. Diameter of flower at the time of harvest (cm)

The data regarding the effect of different gamma irradiation treatments on mean diameter of flower of marigold at the time of harvest is presented in Table 8 and graphically depicted in Fig. 7.

It is seen from the data presented in Table 8 that the different treatments had a significant influence on diameter of flower. The treatment 25 Gy i.e. $T_2$ recorded maximum diameter of flower (5.14 cm) which was at par with $T_3$ (4.84 cm) and significantly superior over the remaining treatments. Minimum flower diameter (4.58 cm) was recorded in treatment $T_7$.

**Table 8:Effect of different gamma irradiation treatments on diameter of flower at the time of harvest of marigold.**

| Sr. No. | Treatment No. | Treatments | Diameter of flower (cm) |
|---|---|---|---|
| 1 | $T_1$ | Control | 4.91 |
| 2 | $T_2$ | 25 Gy | 5.14 |
| 3 | $T_3$ | 50 Gy | 4.84 |
| 4 | $T_4$ | 75 Gy | 4.79 |
| 5 | $T_5$ | 100 Gy | 4.73 |
| 6 | $T_6$ | 125 Gy | 4.64 |
| 7 | $T_7$ | 150 Gy | 4.58 |
| S. E. ± | | | 0.10 |
| C. D. at 5 % | | | 0.31 |

### 4.2.4. Number of flowers per plant

The data in respect to an important character i.e. number of flowers per plant as a result of various gamma

irradiation treatments, is presented in Table 9 and graphically illustrated in Fig. 8.

The data revealed that the different gamma irradiation treatments significantly affected the number of flowers per plant. The maximum number of flowers per plant was recorded in treatment $T_2$ (37.20) which was significantly superior to the remaining treatments and control. The number of flowers per plant was found to be minimum in treatment $T_7$ (27.53).

**Table 9:Effect of different gamma irradiation treatments on number of flowers per plant of marigold.**

| Sr. No. | Treatment No. | Treatments | Number of flowers per plant |
|---|---|---|---|
| 1 | $T_1$ | Control | 31.13 |
| 2 | $T_2$ | 25 Gy | 37.20 |
| 3 | $T_3$ | 50 Gy | 34.67 |
| 4 | $T_4$ | 75 Gy | 30.87 |
| 5 | $T_5$ | 100 Gy | 29.40 |
| 6 | $T_6$ | 125 Gy | 28.80 |
| 7 | $T_7$ | 150 Gy | 27.53 |
| S. E. ± | | | 0.59 |
| C. D. at 5 % | | | 1.83 |

### 4.2.5. Length of peduncle (cm)

The data regarding difference in length of peduncle (cm) in marigold due to different gamma irradiation treatments presented in Table 10 and graphically shown in Fig. 9.

The length of peduncle was significantly affected by the different gamma irradiation treatments. The length of peduncle increased significantly in treatment of 25 Gy (6.57 cm) which was at par with control (6.42 cm) and treatment $T_3$

(6.36 cm). Peduncle length reduced drastically at treatment $T_7$ i.e. 150 Gy which gave flowers with minimum peduncle length (5.48 cm).

**Table 10:Effect of different gamma irradiation treatments on length of peduncle of marigold.**

| Sr. No. | Treatment No. | Treatments | Length of peduncle (cm) |
|---|---|---|---|
| 1 | $T_1$ | Control | 6.42 |
| 2 | $T_2$ | 25 Gy | 6.57 |
| 3 | $T_3$ | 50 Gy | 6.36 |
| 4 | $T_4$ | 75 Gy | 5.65 |
| 5 | $T_5$ | 100 Gy | 5.64 |
| 6 | $T_6$ | 125 Gy | 5.59 |
| 7 | $T_7$ | 150 Gy | 5.48 |
| S. E. ± | | | 0.19 |
| C. D. at 5 % | | | 0.58 |

### 4.2.6. Petal colour

The colour of fully opened flower was recorded by comparing their colour with colour shades mentioned in Royal Horticultural Society colour chart.

The data presented in Table 11 revealed that the different gamma irradiation treatments did not show variation in petal colour of flowers in treated and untreated plants. The Orange colour was observed in all the plants.

**Table 11:Effect of different gamma irradiation treatments on petal colour of marigold.**

| Sr. No. | Treatment No. | Treatments | Petal colour |
|---|---|---|---|
| 1 | $T_1$ | Control | Orange |
| 2 | $T_2$ | 25 Gy | Orange |
| 3 | $T_3$ | 50 Gy | Orange |
| 4 | $T_4$ | 75 Gy | Orange |
| 5 | $T_5$ | 100 Gy | Orange |
| 6 | $T_6$ | 125 Gy | Orange |
| 7 | $T_7$ | 150 Gy | Orange |

### 4.2.7. Flower form

With visual observation of each plant within the treatment, there was no variation observed in flower form between treated and untreated plants of marigold.

**Table 12:Effect of different gamma irradiation treatments on flower form of marigold.**

| Sr. No. | Treatment No. | Treatments | Flower form |
|---|---|---|---|
| 1 | $T_1$ | Control | Ruffled florets |
| 2 | $T_2$ | 25 Gy | Ruffled florets |
| 3 | $T_3$ | 50 Gy | Ruffled florets |
| 4 | $T_4$ | 75 Gy | Ruffled florets |
| 5 | $T_5$ | 100 Gy | Ruffled florets |
| 6 | $T_6$ | 125 Gy | Ruffled florets |
| 7 | $T_7$ | 150 Gy | Ruffled florets |

# DISCUSSION

# 5. DISCUSSION

The data regarding growth characters and flower characters as influenced by various concentrations of gamma irradiation in marigold is discussed in chapter 4. These results have been discussed in this chapter under appropriate sub headings.

## 5.1 Growth characters

### 5.1.1 Survival percentage

The result obtained regarding the effect of various doses of gamma radiation on the growth characters revealed that survival percentage decreased with the increasing concentration of gamma radiation. The Survival percentage under control, 25 Gy, 50 Gy and 75Gy was 100 per cent which was higher in comparison with the rest of the treatments. This can be attributed to the fact that some morphological abnormalities developed after exposure to gamma rays due to physiological disturbances of growth substances and genetic losses due to chromosomal aberrations reported by Tiwari and Kumar (2011). Similar trend has been observed by Banerji and Datta (1992) and Mahure *et al.* (2010) in chrysanthemum. These results also corroborate with the findings of Singh *et al.* (2009) in marigold.

### 5.1.2 Plant height

The plant height differed significantly in various treatments after exposure of gamma rays on marigold seeds.

Treatment $T_1$ (control) recorded maximum plant height (57.39cm) while treatment $T_7$ (150 Gy) recorded minimum plant height (52.10 cm). It was observed that the plant height reduced with increasing doses of gamma irradiations. The present findings are in agreement with the results reported by Banerji and Datta (2002) in cv. Lalima of chrysanthemum, they concluded that inactivation of auxin and decrease in auxin content and the nature and extent of chromosome damage with increase in radiation is responsible for plant height reduction. Reduction in plant height with increase in dose of gamma rays was observed which is in line with findings reported by Dwivedi *et al.* (2000), Boersen *et al.* (2007) and Mahure *et al.* (2010).

### 5.1.3 Number of branches per plant

Treatment $T_2$ (25Gy) had a significant influence on the number of branches per plant. The highest number of branches per plant (6.13) was recorded at 25 Gy treatment. The higher doses of gamma rays were not effective in increasing the number of branches per plant in comparison with control. The number of branches per plant was found to be maximum in treatment $T_2$ (25Gy), while in remaining treatments number of branches per plant decreased with increasing doses of gamma rays. Kumari *et al.* (2013) reported that the less number of branches may be due to inhibitory effect of higher doses of gamma rays. Sax (1963) reported stimulation of plant growth with lower doses of ionising radiation. These results are in agreement with those of Singh *et al.* (2009) who reported that the number of

branches per plant decreases with increase in concentration of gamma rays in marigold. These results on number of branches per plant are in close conformity with results reported by Banerji and Datta (1991, 2002) in 'Anupam' and 'Lalima' varieties of chrysanthemum.

### 5.1.4 Plant spread

Gamma rays treatment $T_2$ had significant influence on the East-West and North-South plant spread while the treatments with higher concentration of gamma rays were found ineffective in increasing the spread of plants in comparison with control. The East-West and North-South plant spread (26.30 cm and 24.47 cm respectively) was found maximum with the exposure of lowest treatment dose i.e. 25 Gy of gamma rays. The results in respect of plant spread exhibited a similar trend to that observed for number of branches per plant. These results are in agreement with those of Singh *et al.* (2009) who reported decrease in East-West and North-South plant spread with the increase in concentration of gamma irradiation in African marigold.

## 5.2 Flowering characters

### 5.2.1 Number of days required for flower bud initiation.

The number of days required for first flower bud emergence was significantly affected by different treatments of gamma radiations. The treatment $T_2$ (25 Gy) gave early emergence of flower buds by 4.47 days in comparison with control which took the maximum number of days for first bud initiation. Delay in the emergence of flower bud with the

increasing concentration of gamma irradiation treatments was found. Due to irradiation, many biosynthesis pathways are altered which are directly or indirectly associated with the flowering physiology (Mahure *et al.* 2010). These results are in agreement with those of Kumari *et al.* (2013) who reported that treatment with higher concentration of gamma radiation resulted in delay in emergence of flower bud in chrysanthemum.

### 5.2.2. Number of days required for flower opening.

The days require for first flower opening was significantly affected by different concentration of physical mutagens. The flower bud opening took place earlier in treatment $T_2$ (25 Gy) in comparison with other treatment and control. Significant delay in flower opening was noticed in treatment $T_7$. In general, number of days required for flower opening was increased with the increase in the concentration of gamma irradiation treatments. These results also corroborate with the findings of Banerji and Datta (1991, 2002), Datta and Banerji (1993); Singh *et al.* (2009) and Tiwari and Kumar (2011) in chrysanthemum and marigold respectively.

### 5.2.3 Diameter of flower at the time of harvest

The diameter of the flower at the time of harvest as a result of gamma irradiation was found to be significant. In treatment $T_2$ (25 Gy) increased flower diameter by 4.68 per cent was observed in comparison to control. Flower diameter got reduced significantly with increasing rate of gamma

irradiation and the reduction was more in higher doses. The beneficial effects of gamma radiation on flower characters were reported by few workers. Singh *et al.* (2009) reported that African marigold responds well to gamma radiation. The gamma radiations have a beneficial effect on the fast growing meristematic tissue. It also affects cell division, cell development and carbohydrate metabolism. As a result of irradiation many biosynthetic pathways are altered which are directly or indirectly associated with the flowering physiology. (Mahure *et al.* 2010)

### 5.2.4. Number of flowers per plant.

The yield in respect of number of flowers harvested from the net plot was significantly increased with treatment $T_2$ in comparison with other treatment and control. The rise in yield in respect of number of flowers per plant was 19.49 per cent in comparison with control. These results are in agreement to those reported by Singh *et al.* (2009) who reported that in African marigold the lower doses of gamma radiations were found beneficial in increasing the number of flowers per plant. The vigorous plant might have given the maximum number of branches which appear to be responsible for increasing the number of flowers per plant as the increase in number of branches must have given higher number of flower buds and thereby increasing number of flower per plant. Kumari *et al.* (2013) reported that the increase in doses of gamma rays had significantly reduced the number of flowers per plant and this may be due to decrease in number of branches. Reduction in number of

flowers with the increasing gamma irradiation treatments corroborates the findings of Datta and Banerji (1993), Dwivedi (2000) and Banerji and Datta (2002).

### 5.2.5. Length of peduncle (cm)

Peduncle length of flower is an important attribute with regard to market value of flower. Significant differences were observed in length of peduncle among various treatments under study. Reduction in length of peduncle with increase in dose of gamma irradiation was recorded except in lowest treatment dose 25 Gy where increase in the length of peduncle was observed in comparison with control. The beneficial effect of gamma radiation at a concentration of 25 Gy i.e. $T_2$ appears to be due to increase in growth of plants. The results are in line with findings reported by Singh *et al.* (2009) in marigold. Kole and Meher (2005) reported increased length of peduncle at lower doses of 5 kR followed by decrease at higher doses of 10 kR and onward as compared to non-irradiated control in *Zinnia elegans* which is in conformity with the results observed.

### 5.2.6. Petal colour

Petal colour of flower as a result of effect of gamma irradiation was found to be non significant. There was no variation in petal colour of flowers obtained from treated plant. This can be attributed to the fact that no chimeric growth was developed in shoot as result of mutagenesis. Shoots of tissues without chimeric growth lead to non formation of different colour variation in petal. However,

Nikaido and Onosawa (1989), Banerji and Datta (1991, 2002), Dwivedi *et al.* (2000) and Misra *et al.* (2009) reported colour change in chrysanthemum after treating with various doses of gamma radiation.

### 5.2.7. Flower form

Different flower form or irregularity in shape of flower due to asymmetrical development of ray-florets with attractive shape and forms are considered as novelties for selecting mutants for commercialisation. The results in respect of flower form exhibited a similar trend to that observed for petal colour that is in all the treated and untreated ruffled florets were observed. However, Banerji and Datta (1992) reported that percent mutation in ray floret shape (tubular) could be induced in cv. Jaya of chrysanthemum. Siranut *et al.* (2000) reported that the number of ray florets varied from semidouble to double in chrysanthemum after gamma irradiation treatments. Banerji and Datta (2002) induced flower shape mutation in chrysanthemum cv. 'Lalima' which is very attractive due to pompon flower head. Increased frequency of plants with double flower, compact flowers and disc florets changed to ray florets increased with increase in radiation was reported by Kole and Meher (2005) in Zinnia.

# SUMMARY AND CONCLUSION

## 6. SUMMARY AND CONCLUSION

The present investigation entitled “Effect of gamma irradiation on morphological characters of marigold (*Tagetes erecta* L.) was carried out during the year 2013-14 at the Modibaug, Department of Horticulture, College of Agriculture, Pune-411 005 with the view to find out effect of gamma radiation on morphological characters of marigold. The experiment was laid out in randomized block design with seven treatment replicated three times. The observation in respect of growth and flowering characters were recorded. The data was statistically analyzed. The results are summarized in this chapter.

The result obtained in respect of growth and flowering characters as influenced by various treatments of gamma radiations are summarized below.

1. The growth characters of plant as represented by plant height, number of branches per plant and spread of plant decreased significantly with the increase in doses of gamma irradiation.

2. The period of emergence of first flower bud and flower opening was significantly delayed with the increase in doses of gamma irradiation. The earliest emergence of flower bud was observed in the lowest dose of gamma irradiation (25 Gy).

3. With increasing dose of gamma irradiation, there was decrease in diameter of flower.

4. The length of peduncle was highest in the lowest dose of treatment.

5. Due to stimulatory effect of gamma irradiation almost 19.49 per cent increase in number of flowers per plant over control was observed in treatment $T_2$ (25 Gy).

6. There was no variation found in petal colour and flower form between treated and control plants.

7. The various levels of gamma rays did not have a significant influence on survival percentage of plants.

**Conclusion**

From this research work, it can be concluded that gamma irradiation has its significance in creating morphological variations and it holds immense scope and significance for induction of mutation. More work in precise technical manner in future is essential for commercially desirable characters. Gamma irradiation of 25 Gy was found best treatment for promising growth and flowering in African marigold cv. Pusa Narangi Gainda.

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# APPENDIX

# APPENDIX

## Pune Weekly Weather Data 2013

| Met. Week | Tmax (°C) | Tmin (°C) | R H I (%) | R H II (%) | RAIN (mm) | R.D (d) | B S S (hr) |
|---|---|---|---|---|---|---|---|
| 1 | 32.0 | 15.1 | 93 | 27 | 0.0 | 0.0 | 8.9 |
| 2 | 30.1 | 10.4 | 95 | 32 | 0.0 | 0.0 | 8.6 |
| 3 | 31.3 | 11.5 | 93 | 32 | 0.0 | 0.0 | 8.0 |
| 4 | 31.1 | 11.4 | 94 | 27 | 0.0 | 0.0 | 8.5 |
| 5 | 31.7 | 14.7 | 82 | 33 | 0.0 | 0.0 | 7.0 |
| 6 | 31.4 | 14.7 | 90 | 36 | 0.0 | 0.0 | 8.0 |
| 7 | 32.9 | 15.1 | 90 | 26 | 0.0 | 0.0 | 7.9 |
| 8 | 33.5 | 12.6 | 85 | 22 | 0.0 | 0.0 | 9.9 |
| 9 | 34.2 | 12.4 | 81 | 16 | 0.0 | 0.0 | 9.7 |
| 10 | 35.2 | 14.0 | 71 | 19 | 0.0 | 0.0 | 9.5 |
| 11 | 35.6 | 16.7 | 73 | 19 | 0.4 | 0.0 | 8.5 |
| 12 | 35.7 | 16.1 | 63 | 17 | 0.0 | 0.0 | 9.4 |
| 13 | 36.2 | 17.3 | 62 | 19 | 0.0 | 0.0 | 8.5 |
| 14 | 36.8 | 16.6 | 58 | 14 | 0.0 | 0.0 | 9.9 |
| 15 | 38.7 | 20.1 | 50 | 15 | 0.0 | 0.0 | 9.5 |
| 16 | 35.5 | 19.1 | 68 | 22 | 0.0 | 0.0 | 10.8 |
| 17 | 38.4 | 22.6 | 55 | 20 | 0.0 | 0.0 | 10.1 |
| 18 | 39.4 | 23.8 | 48 | 20 | 0.0 | 0.0 | 10.1 |
| 19 | 38.2 | 23.2 | 57 | 22 | 0.0 | 0.0 | 10.1 |
| 20 | 36.7 | 24.7 | 66 | 30 | 0.0 | 0.0 | 8.1 |
| 21 | 36.5 | 24.9 | 67 | 37 | 0.0 | 0.0 | 8.7 |
| 22 | 35.7 | 24.3 | 69 | 40 | 0.1 | 0.0 | 9.0 |
| 23 | 33.1 | 22.7 | 84 | 55 | 15.6 | 0.6 | 4.3 |
| 24 | 28.6 | 22.8 | 85 | 74 | 15.9 | 0.6 | 1.4 |
| 25 | 29.2 | 22.7 | 83 | 69 | 4.0 | 0.1 | 4.5 |
| 26 | 27.8 | 22.3 | 88 | 78 | 5.2 | 0.6 | 1.3 |
| 27 | 28.1 | 22.3 | 89 | 76 | 2.8 | 0.3 | 2.7 |
| 28 | 26.9 | 21.9 | 87 | 79 | 6.5 | 0.4 | 1.6 |
| 29 | 26.2 | 21.8 | 91 | 88 | 6.5 | 0.7 | 0.1 |
| 30 | 25.7 | 21.7 | 92 | 88 | 11.7 | 1.0 | 0.4 |
| 31 | 26.2 | 21.4 | 89 | 86 | 6.9 | 0.7 | 2.4 |
| 32 | 27.7 | 21.4 | 86 | 72 | 0.6 | 0.0 | 3.4 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 33 | 28.4 | 22.0 | 88 | 70 | 0.3 | 0.0 | 4.6 |
| 34 | 28.2 | 21.7 | 84 | 67 | 0.5 | 0.0 | 4.0 |
| 35 | 29.1 | 20.1 | 87 | 59 | 0.1 | 0.0 | 5.1 |
| 36 | 29.9 | 20.4 | 87 | 62 | 2.0 | 0.3 | 6.2 |
| 37 | 30.8 | 21.4 | 94 | 62 | 17.2 | 0.9 | 4.3 |
| 38 | 28.8 | 21.4 | 88 | 69 | 13.8 | 0.3 | 3.6 |
| 39 | 28.3 | 21.1 | 85 | 67 | 1.0 | 0.1 | 3.5 |
| 40 | 30.4 | 21.3 | 88 | 60 | 2.0 | 0.3 | 7.2 |
| 41 | 30.0 | 20.3 | 86 | 58 | 0.0 | 0.0 | 7.5 |
| 42 | 32.2 | 20.2 | 89 | 46 | 2.5 | 0.1 | 7.1 |
| 43 | 31.8 | 19.9 | 88 | 49 | 0.4 | 0.1 | 7.5 |
| 44 | 31.8 | 18.1 | 87 | 43 | 0.0 | 0.0 | 8.5 |
| 45 | 30.2 | 15.3 | 89 | 40 | 0.0 | 0.0 | 7.9 |
| 46 | 29.2 | 12.5 | 92 | 36 | 0.0 | 0.0 | 9.0 |
| 47 | 31.2 | 14.0 | 92 | 37 | 0.0 | 0.0 | 9.0 |
| 48 | 29.8 | 18.5 | 94 | 53 | 2.1 | 0.1 | 6.3 |
| 49 | 29.1 | 13.1 | 94 | 36 | 0.5 | 0.1 | 7.8 |
| 50 | 29.3 | 7.3 | 94 | 26 | 0.0 | 0.0 | 9.5 |
| 51 | 29.5 | 8.5 | 94 | 31 | 0.0 | 0.0 | 9.3 |
| 52 | 28.7 | 12.9 | 97 | 42 | 0.0 | 0.0 | 7.5 |

# VITA

# VITA

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A candidate for the degree

of

**MASTER OF SCIENCE (HORTICULTURE)**

In

**FLORICULTURE AND LANDSCAPING**

**2015**

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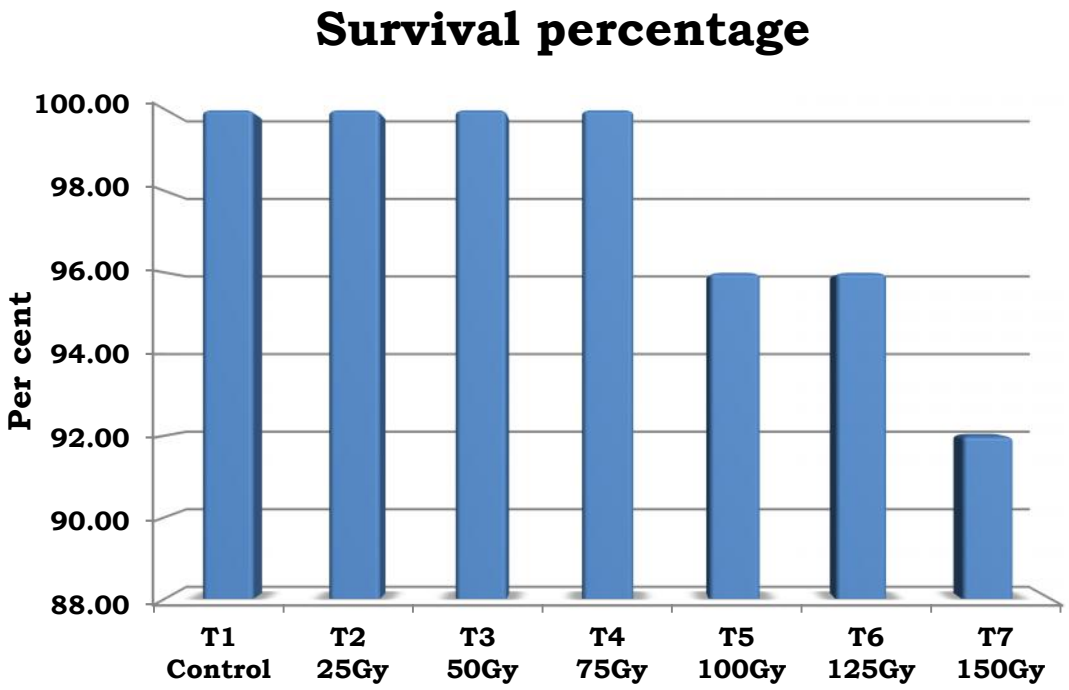


**Fig. 1-Effect of gamma irradiation on survival percentage of marigold.**

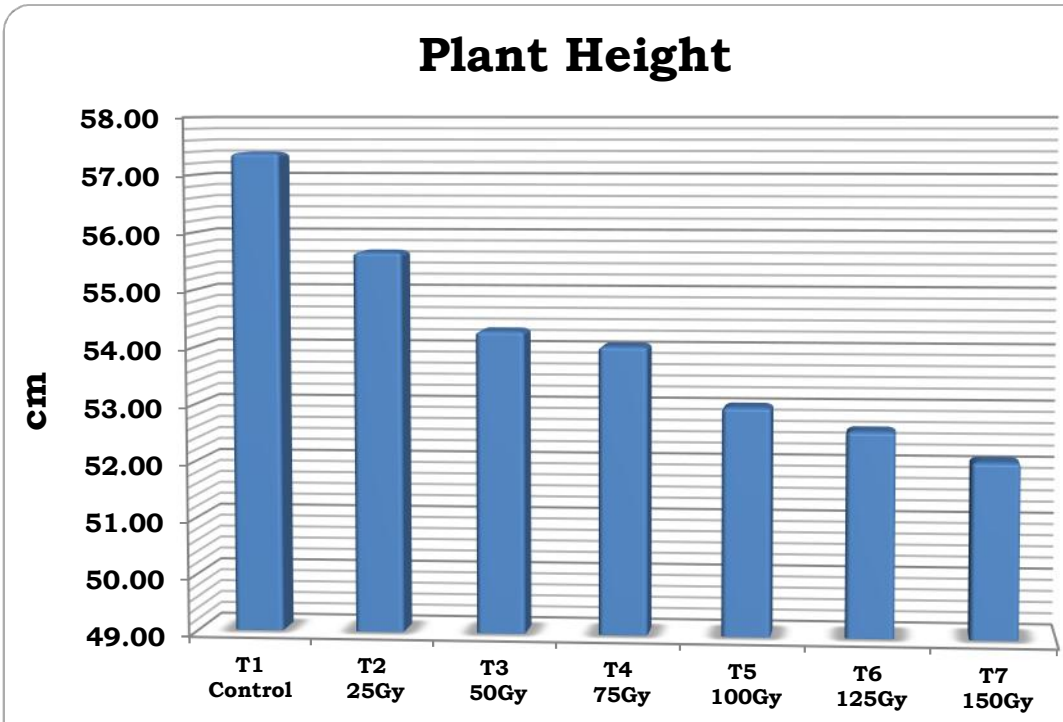


**Fig. 2-Effect of gamma irradiation on plant height of marigold.**

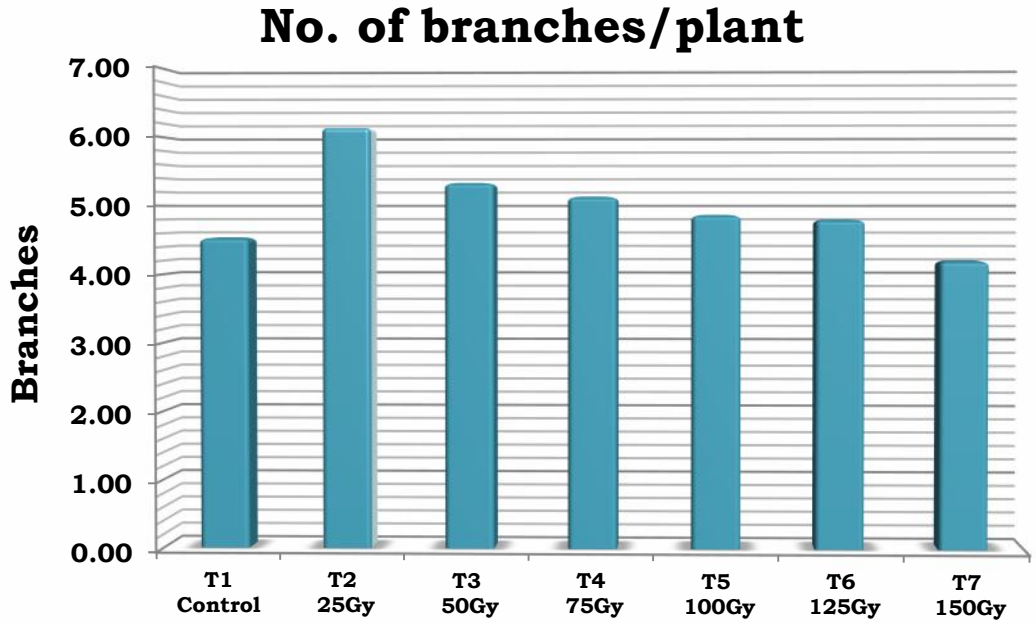


**Fig. 3-Effect of gamma irradiation on number of branches per plant of marigold.**

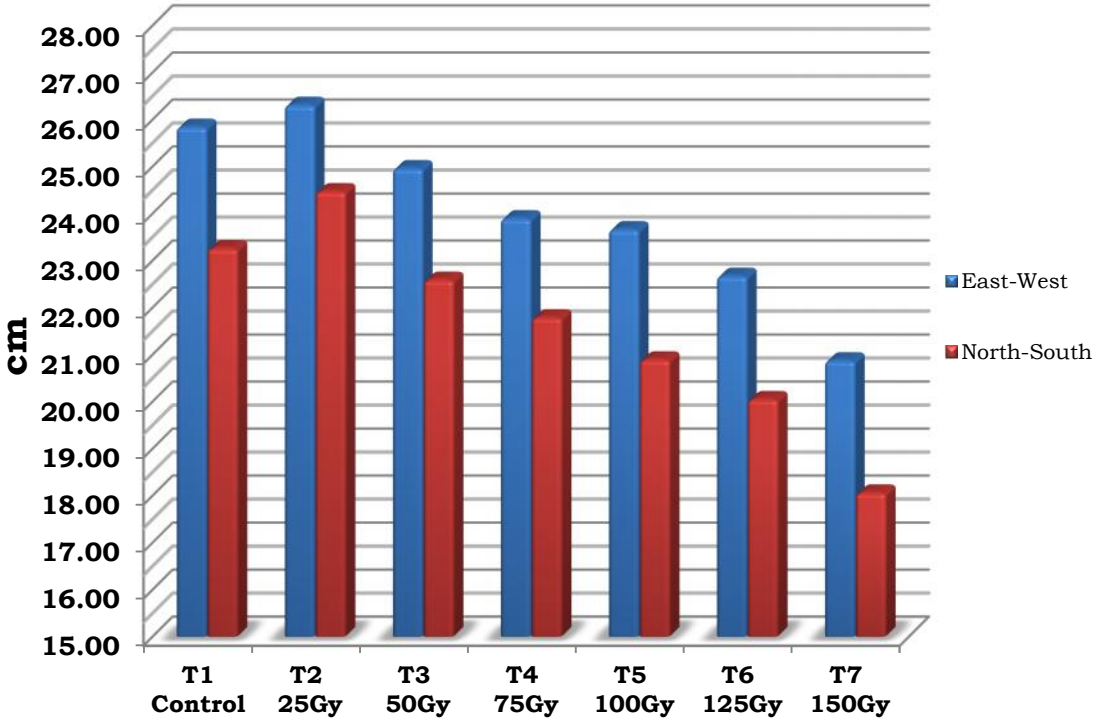


**Fig. 4-Effect of gamma irradiation on plant spread of marigold.**

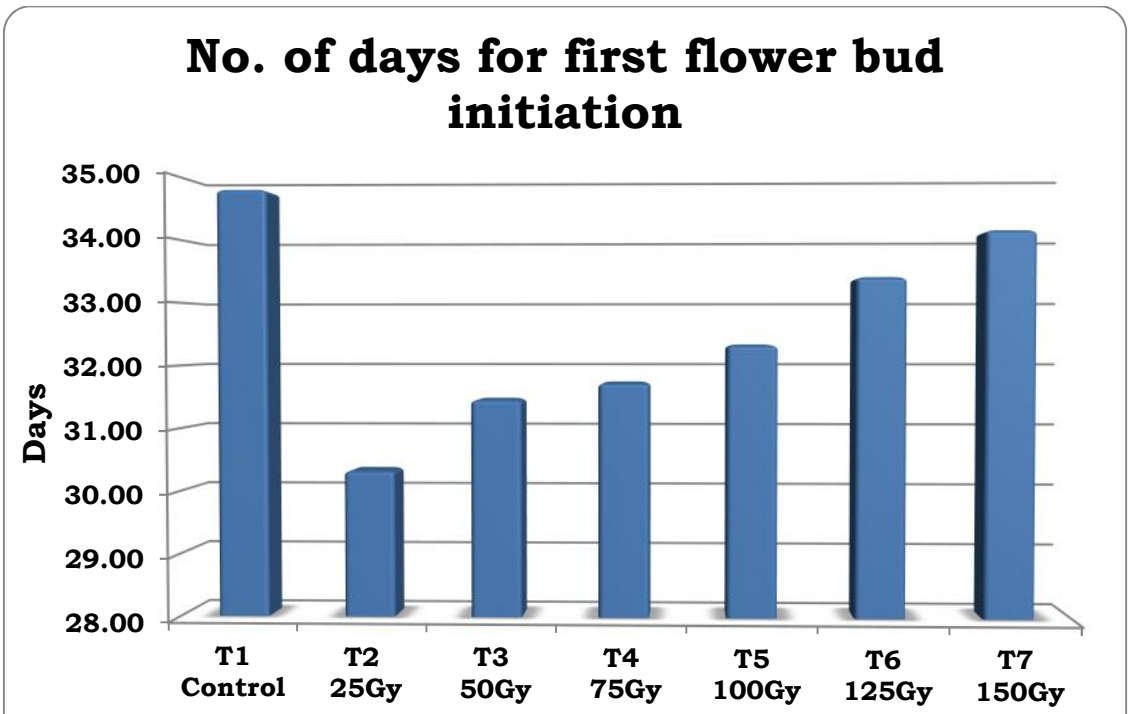


**Fig. 5-Effect of gamma irradiation on number of days required for first flower bud initiation of marigold.**

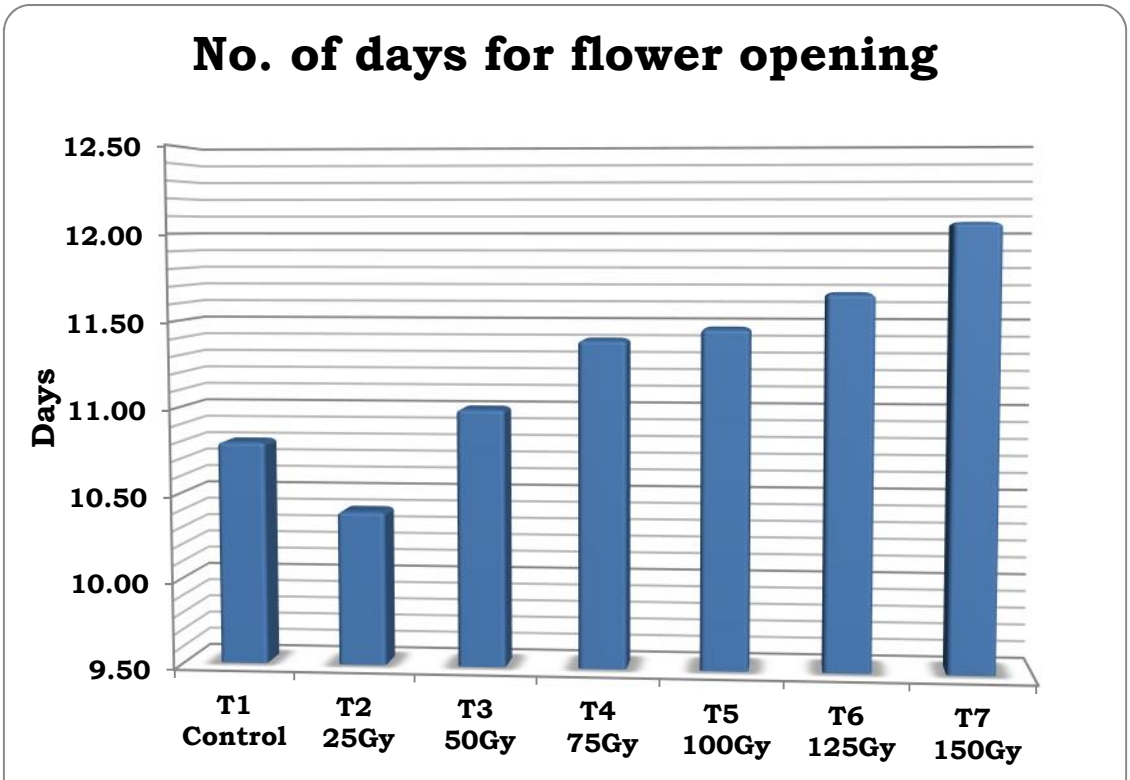


**Fig. 6-Effect of gamma irradiationon number of days required for flowering of marigold.**

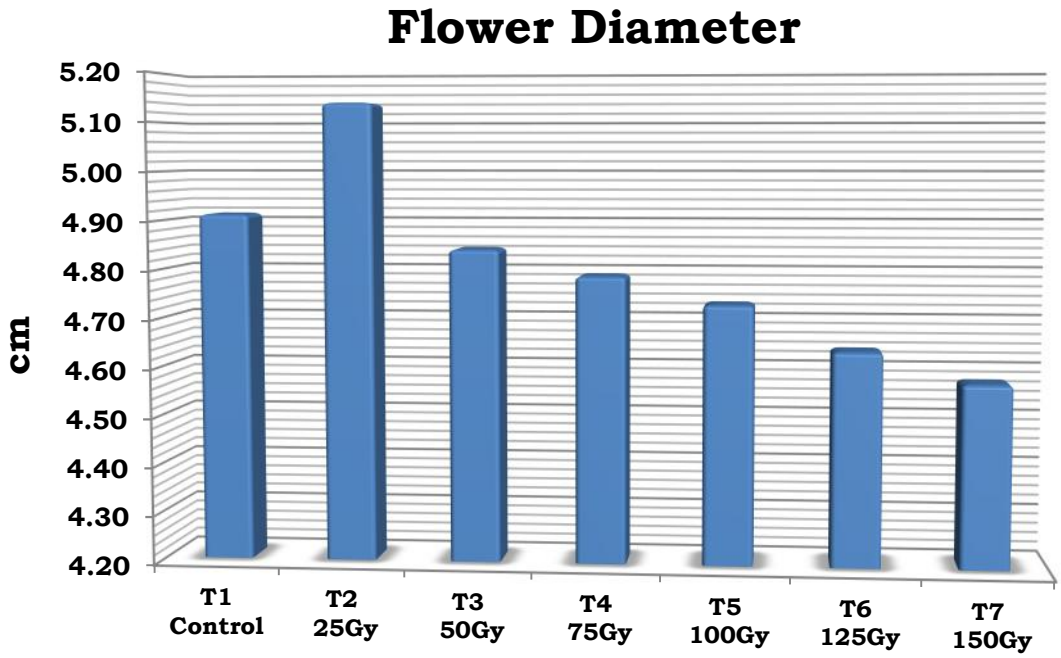


**Fig. 7-Effect of gamma irradiation on diameter of flower at the time of harvest of marigold.**

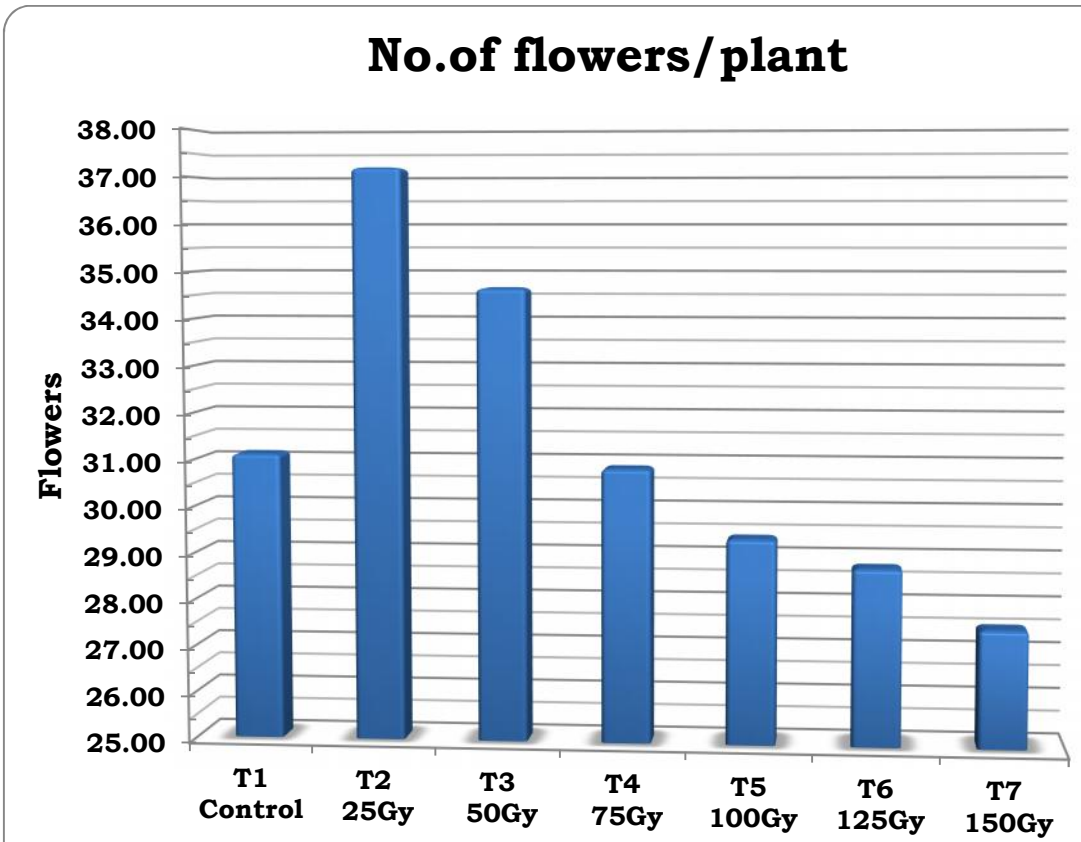


**Fig. 8-Effect of gamma irradiation on number of flowers per plant of marigold.**

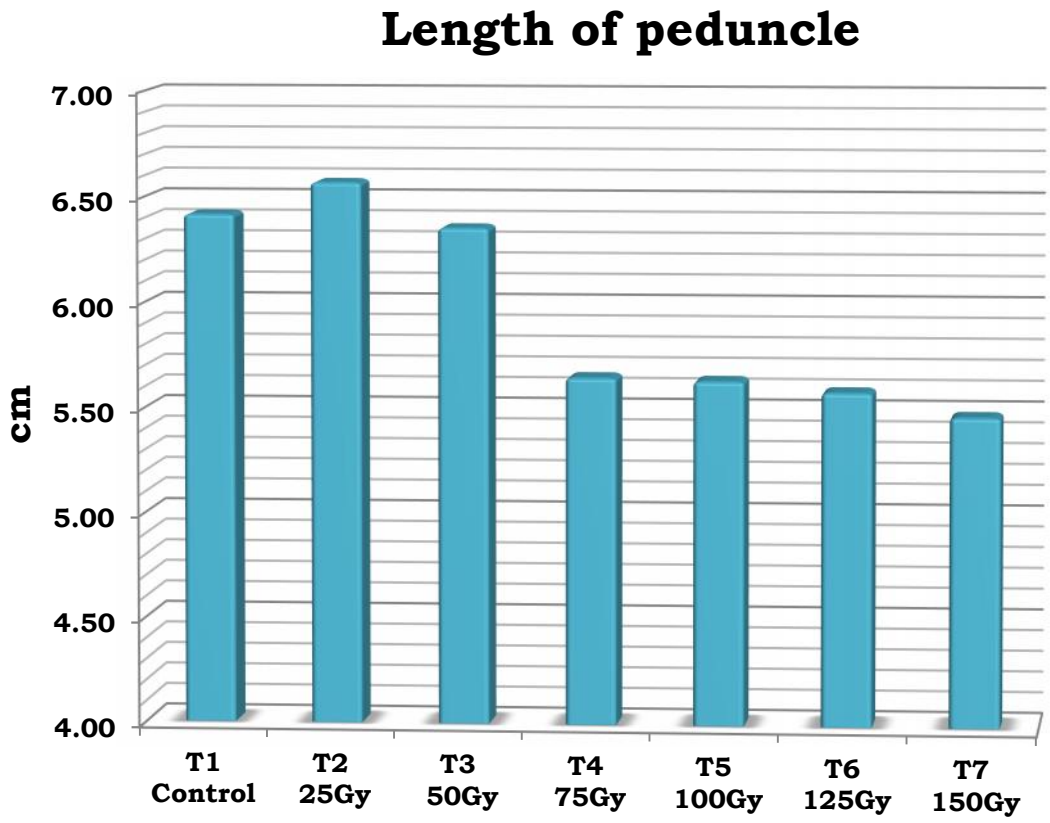


**Fig. 9-Effect of gamma irradiation on peduncle length of marigold**

**Plate No 1- General view of experimental plot**

**Plate No 2- General view of experimental plot**


**Plate No-3 Effect of different gamma irradiation treatments on flower diameter of marigold.**

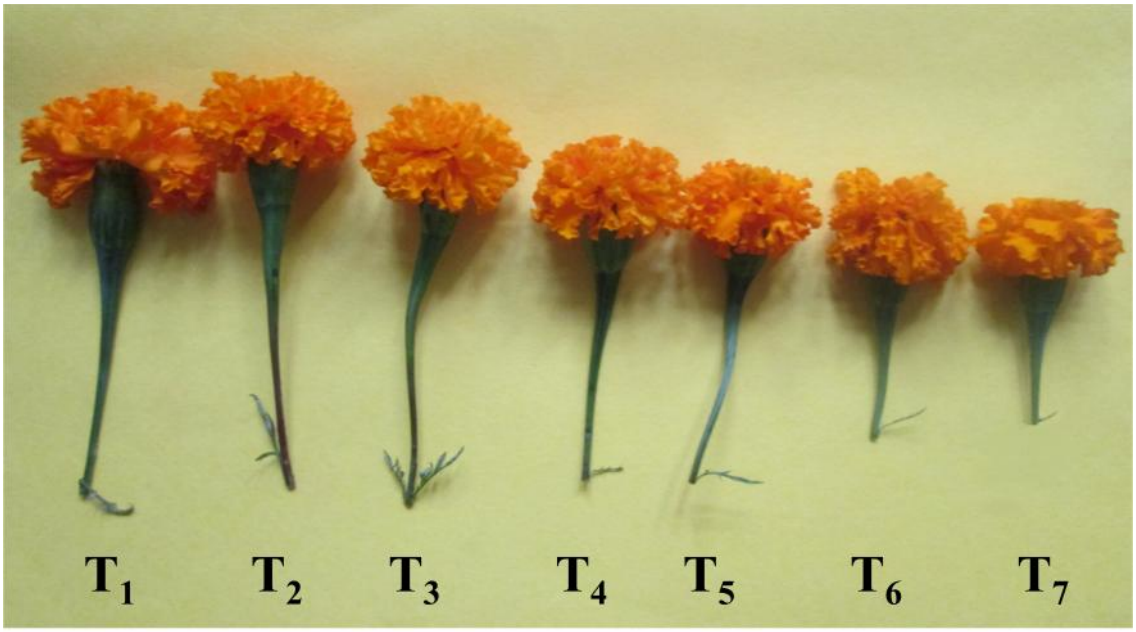


**Plate No-4 Effect of different gamma irradiation treatments on peduncle length of marigold.**