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Effect of gamma irradiation on African marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gainda

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ABSTRACT

Seeds of African marigold cv. 'Pusa Narangi Gainda' were irradiated with 0, 100, 200, 300 and 400 Grays of gamma rays to induce mutation. Seeds were sown just after irradiation and 30-day old seedlings were transplanted into beds. Reduction in survival percentage, plant height, number of branches, leaf number, leaf size, plant-spread, stem diameter, increased foliage and floral abnormalities were observed upon irradiation and with increase in dose of gamma rays. LD_{50} was determined on survival basis. Leaf abnormality manifested itself as leathery texture of leaf, enhanced and irregular leaf thickness, asymmetric development of pinnate leaflets, reduction in pinnae number, chlorophyll variegation, pale and deep green leaves, narrow leaves and small leaves. Percentage of abnormal leaves and plants increased with increase in dose of gamma rays. Fasciation of stem was a common abnormality observed in all the treatments. Days to bud initiation, earliness in colour-appearance and days to full bloom were all significantly delayed upon exposure to gamma rays. Flower-head size, height and weight were highest at the lowest dose. Number of ray florets and size (length and width) decreased with increasing radiation dose. Floral abnormalities and % of plants with abnormal flower-heads increased with increasing dose of gamma irradiation. Floral abnormality included fasciation of flower-head and asymmetric development of ray florets. Stimulating effect of gamma irradiation was observed at 100 Grays where almost all the characters studied showed positive correlation, including growth and yield attributes. It is concluded that exposure to 100 Grays of gamma rays in African marigold cv. Pusa Narangi Gainda results in higher yield and marketable bloom.

Key words: *Tagetes erecta*, African marigold, Pusa Narangi Gainda, gamma irradiation induced mutation

INTRODUCTION

Marigold, a member of the family *Asteraceae*, is native to Central and South America especially Mexico (Kaplan, 1960). The genus comprises thirty species of strongly scented annual and perennial herbs (Anonymous, 1976). Cultivated genera include *Tagetes erecta* L., commonly referred to as African marigold. In addition, the genus is recognized as a source of natural colourant, essential oil and thiophenes. It is one of the most important loose-flower crops grown commercially in many parts of the country. Flowers of marigold are used in garland-making, wreaths, as religious offering, in hall decoration, etc. It is in great demand as loose flower throughout the year. Carotenoids extracted from flowers are used commercially in pharmaceuticals, foods supplements, as animal feed additives and colourants in food and cosmetics. Many workers have tried to improve marigold by breeding resulting in novel cultivars, but, very little work has been done on mutation breeding. Several workers have examined effects of mutagens like gamma irradiation, ethyl methane sulphonate (EMS) and nitrosomethyle urea (NMU) on marigold (Heslot, 1968). Chlorophyll-deficient effects have been noticed in coleoptile of *Tagetes erecta* L. with gamma irradiation by Zaharia (1991). Since few attempts have been made to improve *Tagetes erecta* L. (African marigold) cv. 'Pusa Narangi Gainda', the present investigation was carried out using gamma irradiation as a tool to induce mutation.

MATERIAL AND METHODS

Dry and healthy seeds of African marigold cv. Pusa Narangi Gainda were irradiated with 0, 100, 200, 300 and 400 Grays of gamma rays (^{60}Co). The experiment was conducted at Floriculture Section, National Botanical Research Institute, Lucknow, during the winter of 2007-08

to evaluate effects of gamma irradiation on quantitative traits. Treated seeds were sown along with the control (unirradiated) immediately after irradiation in 30 cm earthen pots and irrigated with a fine spray of water. Transplanting was done at thirty days from sowing. The experiment was conducted in a randomized block design with three replications spacd at 30 cm x 30 cm. In the M_1 population, observations were recorded on various quantitative traits *viz.*, plant height and spread, number of branches/leaves per plant, leaf size, stem diameter, morphological abnormalities in foliage and flower, flowering behaviour (days to bud-initiation, colour appearance and full-bloom); flower-head height, weight and size (length and width), number of ray and disc florets, size of ray florets, fresh and dry weight the flower-head, number of seeds per flower-head and per cent fertile and sterile seeds per flower-head. Chlorophyll was estimated by the method of Arnon (1949).

RESULTS AND DISCUSSION

Reduction in % plant survival, plant height**,** branch number, plant-spread, leaf number and size and stem diameter was observed at 100 Grays exposure of gamma rays. Maximum reduction in these traits was observed in the highest dose (400 Grays). Control plants exhibited hundred per cent survival, with normal growth (Plate 1) and no morphological abnormalities either in leaf or in stem, during various stages of plant growth (right from seedling upto mature flowering stage) while, leaf and stem abnormalities were quite clear and visible during various stages of vegetative growth in the treated population. Survival of plants was with increase in dose. Highest mortality was recorded with 400 Grays of gamma rays where only 68.5% of the plants survived. LD_{50} on survival basis was determined above 400 Grays of gamma rays. Morphological abnormality in leaves manifested as asymmetrical leaf lamina, reduction in leaf size, narrow leaves, laminar fission, leathery texture, deep and pale green leaves and chlorophyll variegation of different grades (Plates 2-4). No significant differences in Chlorophyll a, b or total chlorophyll content were observed upon irradiation. This is in concurrence with findings of Geetha (1992) who reported chlorophyll deficient effects of gamma irradiation on *Tagetes patula* L. Cetl (1985) examined the effect of various concentrations of NMU on *Tagetes erecta* seeds and reported similar results for almost all the parameters studied (plant-height, stem diameter, flower-head size, flower-head height, time of flowering, branching habit, leaf size and flower-stalk length). Stem abnormalities included fasciation and forking (Plate 4). Per cent leaf abnormalities and percentage of plants with morphological abnormalities increased with increas in dose of gamma rays. Higher leaf abnormalities of 53.5% were observed with 400 Grays, in which 82.8% of the population exhibited abnormal plant type (Table 1). Plant-spread significantly ($P<0.001$) declined upon irradiation and with increased dose of gamma rays. Maximum reduction in plant-spread was observed with 400 Grays exposure (Table 1).

Growth rate was measured using two parameters, *viz.* plant height and development of new leaves at fortnightly intervals. At the end of the first fortnight, growth rate was identical in both untreated and treated plants (Fig 1 & 2). In the second fortnight (30 days of growth), difference in plant growth was prominent and effect of gamma irradiation was quite clear. A sharp decline in plant-height and leaf-number was recorded here in the treated population in comparison

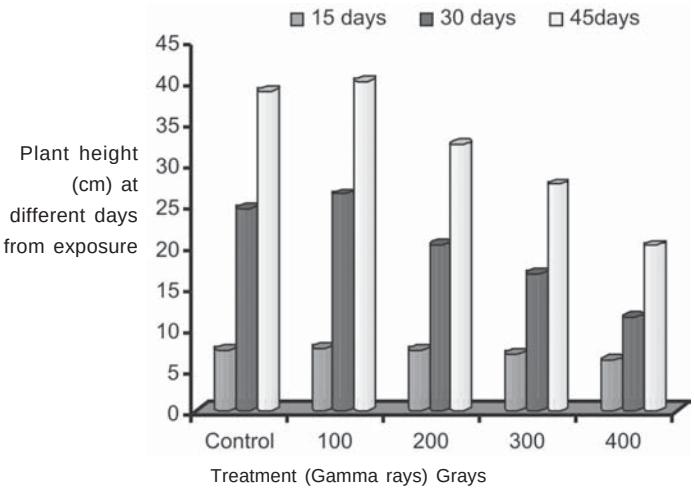

Fig 1. Effect of Gamma irradiation on plant height (cm)

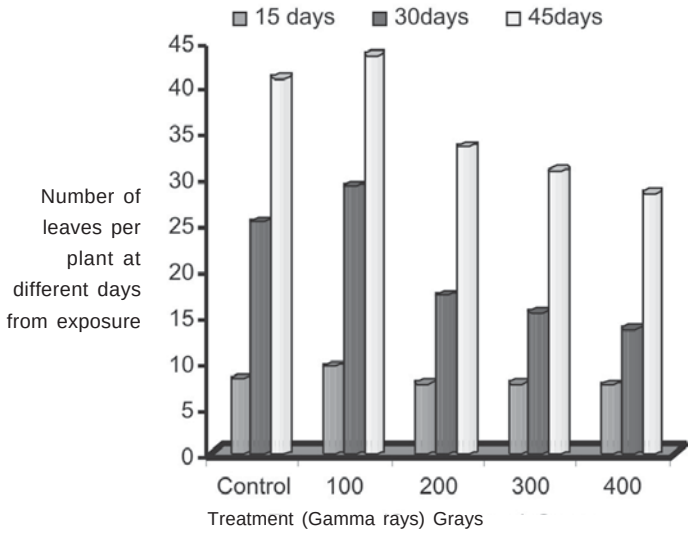

Fig 2. Effect of Gamma irradiation on number of leaves per plant

Table 1. Effect of gamma irradiation on vegetative characters of African marigold cv. Pusa Narangi Gainda

Trait	Treatment with Gamma ray (Grays)				
	0 (Control)	100	200	300	400
	Vegetative parameters				
Survival (%)	100.00	100.00	88.45	79.12	68.53
Plant height (cm) ± SE	62.09	64.43	48.04***	45.65***	40.32***
	±1.41	±1.71	±1.56	±1.47	±1.38
Number of branches/plant ±SE	5.45	6.00	4.80	4.33	3.77
	±0.52	±0.31	±0.36	±0.30	±0.66
N - S Plant-spread (cm) ±SE	29.24	31.26	20.35***	18.63***	17.59***
	±0.81	±0.77	±0.81	±0.57	±0.75
E - W Plant-spread (cm) ±SE	28.35	29.51	21.07***	18.32***	17.20***
	±0.87	±0.79	±0.84	±0.61	±0.64
Number of leaves/plant ±SE	59.90	63.40	45.27***	36.70***	30.90***
	±4.78	±3.73	±3.45	±4.32	±2.06
Leaf length (cm) ± SE	15.94	16.70	12.76***	10.90***	9.78***
	±0.27	±0.25	±0.14	±0.27	±0.27
Leaf width (cm) ± SE	6.94	7.04	5.81***	5.30***	4.52***
	±0.19	±0.16	±0.22	±0.17	±0.19
Stem diameter (cm) ± SE	0.63	0.67	0.50***	0.42***	0.38***
	±0.02	±0.01	±0.01	±0.01	±0.02
% Leaf abnormalities ±SE	0.00	9.37	28.12	31.03	53.57
% Morphologically abnormal plants ±SE	0.00	9.37	37.18	44.82	82.80
	Chlorophyll content (mg/g fresh weight)				
Chlorophyll 'a'	0.035	0.034	0.044	0.036	0.034
Chlorophyll 'b'	0.061	0.061	0.063	0.064	0.059
Total chlorophyll	0.098	0.105	0.101	0.103	0.095

*=P < 0.05; †=P < 0.02; **= P < 0.01; ***= P < 0.001

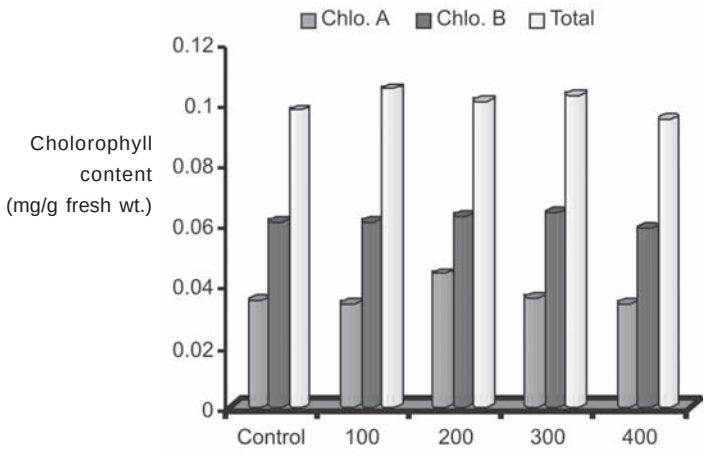

Fig 3. Effect of Gamma irradiation on chlorophyll content

to the control. Plant-height and number of leaves per plant decreased with increasing dose of gamma rays at 200 Grays. At the lowest dose of 100 Grays, stimulation in plant-height and increase in number of leaves per plant was recorded. In the third fortnight (45 days of growth), plant-height and number of leaves per plant were quite similar to that in the second fortnight (Fig 1 and 2).

Chlorophyll estimation was carried out in fresh leaves in both the control and irradiated plants using spectrophotometer (Ultrospec 2000). No significant difference in chlorophylls a, b and total chlorophyll content was observed upon gamma irradiation and with increase in dose. However, a slight increase in chlorophyll `a' content was observed with 200 Grays exposure.

Bud-initiation was seen at 36 days from planting in the control population. It was significantly (P< 0.01) delayed with 200 Grays exposure to gamma rays. The maximum delay of 6 days was observed in the highest dose i.e., 400 Grays (Table 1). First floral-bud colour expression was observed at 49 days from planting and was delayed with 200 Grays exposure. Significant (P< 0.01) delay in first floral-bud colour expression of 9 days was observed (400 Grays) exposure. Full-bloom was noticed at two months from planting in the control population, which was significantly (P< 0.01) delayed with exposure to gamma rays at 100 Grays. Maximum delay of 8 days was observed in the highest dose of 400 Grays. In general, flowering was delayed upon irradiation. Banerji and Datta (1991, 1993, 1995 and 2002) reported similar results in chrysanthemum. Number of flower-heads per plant increased slightly at the lowest dose

(100 Grays), and, progressively decreased with increase in dose. Maximum reduction in flower number, *i.e*., 50%, was observed at 400 Grays.

Flower-head size decreased with increase in gamma ray dose and was significant (P< 0.01) at 200 Grays. Flower-head weight was not overly affected with irradiation. However, number of ray florets per head increased at 100 Grays exposure. Here, an increase of 19 ray florets per head was recorded. But, at 200 Grays exposure, a sharp decline in ray-floret number was observed (25 ray florets fewer per head). Both reduction and increase in ray-floret number was observed with differential irradiation. Number of ray-florets per head increased at 200 Grays (Table 2). Length and width of ray floret significantly (P< 0.01) declined at 200 Grays. Fresh and dry weight of flower was found to increase at 100 Grays, and, a decreasing trend was observed at 2900 Grays. Number of seeds per head was higher at irradiation upto 300 Grays and decreased significantly (P< 0.01) at 400 Grays exposure. Number of fertile seeds significantly (P< 0.01) increased at 100 Grays, fell sharp thereafter. In the control flower-head, 32% seed sterility was observed, while, it declined at 100 Grays and increased again to double that of the control at 400 Grays exposure.

Plant survival, height, leaf-size, number of branches and leaves, and flower-head size declined upon gamma irradiation. Reduction was significant mostly at higher doses. Different types of morphological abnormalities in leaves (changes in shape, size, margin, apex and fission of leaves) and flower-head (shape and size of flower-head, asymmetric development of floret, fasciation of flower-head) were recorded with irradiation (Plate 5-7). Frequency of leaf and floral abnormalities and per cent plants with morphological abnormalities increased with increase in dose. Flowering behaviour was also affected upon irradiation.

Table 2. Effect of gamma irradiation on flowering behaviour and flower yield attributes of African marigold cv. Pusa Narangi Gainda

Trait	Treatment with Gamma ray (Grays)				
	0 (Control)	100	200	300	400
			Flowering behaviour		
Days to bud initiation ±SE	36.32	36.22	40.46**	39.89**	42.43***
	±0.96	±0.77	±0.78	±0.88	±0.98
Days to first-colour ± SE	49.17	48.90	54.24***	56.06***	58.52***
	±0.92	±0.77	±0.87	±0.99	±1.08
Days to full-bloom ± SE	61.40	60.36	66.56***	65.78***	69.03***
	±0.97	±0.36	±0.49	±0.64	±0.83
Number of flower heads/plant ±SE	7.67	9.14*	5.67***	4.77***	3.39***
	±0.44	±0.49	±0.36	±0.29	±0.19
Flower-head size (cm) ± SE	7.04	7.64	6.60**	6.52***	5.66***
	±0.16	±0.09	±0.11	±0.05	±0.12
Flower-head height (cm) ± SE	4.88	5.02	4.60	4.38***	4.28***
	± 0.07	± 0.05	± 0.15	± 0.10	± 0.20
Number of ray florets/head ±SE	115.80	134.80*	98.20	96.20	90.80†
	±7.85	±3.38	±6.44	±6.80	±5.37
Number of disc florat/head ±SE	98.80	91.80	125.60**	131.60***	111.50
	±7.60	±6.44	±2.99	±4.62	±2.28
Ray floret length (cm) ±SE	2.69	2.88	2.58	2.10***	1.52***
	±0.10	±0.01	±0.01	±0.02	±0.05
Ray floret width (cm) ±SE	1.84	2.02	1.54***	1.41***	1.40***
	±0.01	±0.02	±0.02	±0.03	±0.02
Fresh weight of flower-head (g) ±SE	7.54	8.16	6.80**	6.52***	5.28***
	±0.17	±0.20	±0.20	±0.21	±0.37
Dry weight of flower-head (g) ±SE	1.05	1.13	0.91	0.80	0.53
	± 0.31	± 0.50	± 0.29	± 0.42	± 0.53
Number of seeds/head ±SE	198.50	213.60	205.10	207.60	170.50***
	± 6.20	± 5.41	±5.20	±7.49	± 5.80
% Fertile seed ±SE	68.18	75.86***	58.33***	51.33***	40.87***
	± 0.95	± 0.85	±0.91	± 0.86	±0.80
% Sterile seed ±SE	31.82	24.14**	41.67***	48.67***	59.13***
	±0.49	±0.58	±0.41	±0.39	±0.51

*=P < 0.05; †=P < 0.02; **= P < 0.01; ***= P < 0.001

Reduction in 'survival to maturity' and plant-height upon treatment with gamma rays may be due to inactivation of auxins and a decrease in auxin content with increased irradiation dose. Banerji and Datta (1993, 2002) explained that survival of plants to maturity and plant- height depended upon the nature and extent of chromosome damage. Percentage of abnormal leaves/plant increased with increase in exposure to gamma rays. Increase in plant-height and flower-production at lower doses was due to the stimulating effect of gamma rays. This effect of gamma rays has been recorded with 100 Grays exposure where plant-height, branch number, plant-spread (N-S & E-W), number of leaves, flower-heads, ray florets and seeds per flower increased (Tables 1 & 2). Sax (1963) and Sparrow (1954) reported stimulation of plant-growth with lower doses of ionizing radiation. Decrease in leaf and flower-head number with higher doses might be due to decrease in branch number (Banerji and Datta, 2001). Floral abnormalities increased upon irradiation. Banerji and Datta (1990, 1992, 2002 and 2003) also reported similar type of floral abnormalities in different cultivars of chrysanthemum with gamma irradiation. On the whole, this study revealed that exposure of seeds at 100 Grays is best among the doses studied, for improving growth and yield in the above stated variety of marigold.

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