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Effect of different plant growth retardants on plant growth, flowering and yield of African marigold (*Tagetes erecta* L). cv. Pusa Basanti

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Abstract
The field experiment entitled "Effect of different plant growth retardants on plant growth, flowering and yield of African Marigold (*Tagetes erecta* L). cv. Pusa Basanti" was carried out at Horticultural Experimental Field, Department of Horticulture, Sam Higginbottom Institute of Agriculture, Technology and Sciences, Deemed-to-be University, during rabi season of 2014-2015. Ten treatment combinations with one cultivar were tried in Randomized Block Design (RBD) with three replications. Treatment details were T_0 (Control), T_1 (CCC @ 750 ppm), T_2 (CCC @ 1000 ppm), T_3 (CCC @ 1250 ppm), T_4 (Ethephon @ 250 ppm), T_5 (Ethephon @ 500 ppm), T_6 (Ethephon @ 750 ppm), T_7 (MH @ 200 ppm), T_8 (MH @ 300 ppm) and T_9 (MH @ 400 ppm). On the basis of investigation, it may be concluded that treatment T_2 with (CCC @ 1000 ppm) was found to be best treatment in terms of growth and flowering parameters observed viz., Plant height (46.87 cm), no. of branches per plant (5.78), plant spread (39.33), leaves per plant (679.13), days taken for first flower bud initiation (50.38), days taken for first flowering after transplanting (61.23), diameter of flower (5.94 cm), flower stalk length (8.84 cm). This treatment also showed maximum yield parameters viz., no. of flowers per plant (24.12), flower yield per plant (210.09 g), flower yield per ha (13.13 t/ha) and flower quality by observing fresh flower weight (12.67 g) in African marigold (*Tagetes erecta* L). cv. Pusa Basanti. The economics analysis reveals that maximum benefit cost ratio (1: 2.69), net income, gross income are maximum with this treatment.

Keywords: Marigold (*Tagetes erecta* L), Pusa Basanti, Chloromequat chloride, Ethephon, Maleic hydrazide

1. Introduction
Floriculture is a fast growing agri-industry in India. It has become as important sector experiencing rapid change in the world over. In India, floriculture has been associated with culture and heritage since very ancient time and has long tradition of growing flowers largely for religious purposes, perfume industry and landscaping. At international level with increasing consumption, production has increased and non-traditional areas have emerged as important players in floriculture.

About 160.7 thousand ha of area is under floriculture producing 870.4 thousand MT of loose flower and 43417.5 million cut flowers annually in India. However, India exported floricultural products of Rs. 699.85 crore during 2013-14 (Kumar *et al.*, 2014) [7]. Tamil Nadu is the leading producer of loose flowers closely followed by Andhra Pradesh and Karnataka both in terms of area and production. Around 77% of area under floricultural crops is mainly concentrated in seven states comprising of Tamil Nadu, Karnataka, Andhra Pradesh, West Bengal, Maharashtra, Haryana, Uttar Pradesh and Delhi. Uttarakhand producing 0.98 MT loose flowers and 1727 lakhs cut flower from 0.94 thousand ha area.

Marigold is a native of central and South America especially Mexico, belongs to Asteraceae family (Iltis, 1945) [6]. Marigold (*Tagetes erecta* L.*)*, occupies a prominent place in ornamental horticulture. Marigold is also known as friendship flower in United States and student lumen (student's flower) in Germany. It spreads to different parts of world during early part of 16th century from Mexico (Bailey 1963) [2] mentioned that French marigold was put into cultivation in 1573 AD. and African marigold in 1596 AD. in Europe. In India, it is thought to be introduced by Portuguese between 1502-1550 (Mehra, 1966) [8]. Marigold occupies the top most position 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.

Marigold is mainly grown in India, Tropical Africa, Sri Lanka and Madagascar. India occupies 15 per cent of the area for traditional flower in the world. Major marigold producing states are Tamil Nadu, Karnataka, Andhra Pradesh, Maharashtra, West Bengal, Orissa, Delhi, Uttar Pradesh and Uttarakhand. Karnataka is leading state in marigold with production of 49,777 tonnes of flower followed by Delhi (14,570 tonnes) and Orissa (1,458 tonnes).

Growth retardants play an important role in changing both morphology and physiology of plants. The effect of plant growth retardants varies with plant, species, variety, their concentration used method of application, frequency of application and various other factors which influence the absorption and translocation of the chemicals Abadi (2010) [1].

Cycocel slows down the cell division and cell elongation in meristematic tissues of shoot and regulate the plant height without formative effects and change the morphology and physiology of the plant. Ethephon's mode of action can offer benefits other than height suppression. Maleic hydrazide is a synthetic compound which has a plant growth regulating action.

2. Materials and Methods

The field experiment entitled "Effect of different plant growth retardants on plant growth and flowering of African Marigold (*Tagetes erecta* L). cv. Pusa Basanti" was carried out at Horticultural Experimental Field, Department of Horticulture, Sam Higginbottom Institute of Agriculture, Technology and Sciences, Deemed-to-be University, during rabi season of 2014-2015. The detail pertaining to the materials and methods adopted are presented in this chapter. Ten treatment combinations of one cultivar were tried in Randomized Block Design (RBD) with three replications treatment details viz. T_0- Control, T_1- CCC (750 ppm), T_2- CCC (1000 ppm), T_3- CCC (1250 ppm), T_4- Ethephon (250 ppm), T_5- Ethephon (500 ppm), T_6- Ethephon (750 ppm), T_7- MH (200 ppm), T_8- MH (300 ppm) and T_9- MH (400 ppm). The Seeds of African marigold cultivar 'Pusa Basanti Gainda' were procured from Department of Horticulture, Sam Higginbottom Institute of Agriculture, Technology and Sciences, Deemed-to-be University and were sown on 15th September, 2014 to raise the nursery in size (1.0 x 1.3 m). Standard cultural operations like watering, weeding and pinching (30 days after sowing).

3. Result and Discussion

During the present investigation, observations on various plant characteristics were recorded to evaluate the "Effect of different plant growth retardants on plant growth and flowering of African Marigold (*Tagetes erecta* L). cv. Pusa Basanti" The tabulated data were statistically analyzed with a view to find out the significant effect of different factors in terms of vegetative growth, flower yield of African marigold (*Tagetes erecta* L). cv. Pusa Basanti. Which are present under appropriate headings.

3.1 Height of plant (cm)

The minimum plant height (46.73 cm) was observed in the treatment T_3 with (CCC 1250 ppm) followed by treatment T_2 with (CCC 1000 ppm) (46.87 cm). The plant height was found to be maximum (73.27 cm) in the treatment T_0 with control.

The probable reason for decreasing plant height was primarily that these growth regulators are synthetic growth retardant which act in variety of way in natural growth mechanism of plant. They either decrease cell division or inhibit cell elongation and reduce plant height acting in sub-apical system consequently, the plant becomes dwarfish as the internodes fails to elongate.

Similar results were also reported by Verma and Arha (2004) and Sunitha *et al*. (2007) found in Marigold, Dubey (2005) in (Gladiolus) and Kumar *et al.* (2014) in (Marigold) were also observed similar result in their experiments [12, 10, 4, 7].

3.2 Number of branches per plant

The maximum number of branches per plant (7.45) was observed in the treatment T_9 with (MH 400 ppm) followed by treatment T_8 with (MH (300 ppm) (6.92). The number of branches per plant was found to be minimum (6.03) in the treatment T_2 with (CCC 1000 ppm).

MH severely inhibited growth of plant. At low doses MH broke apical dominance and side branches were developed. Suggestion is made that the inhibition of shoot growth induced by MH is due to primarily blocking the activity of the hormones. Similar results were also reported by Verma and Arha (2004) and Gautam *et al.,* (2005) in marigold [12].

3.3 Plant Spread (cm)

The maximum Plant Spread (cm) (48.60) was observed in the treatment T_8 with (MH 300 ppm) followed by treatment T_9 with (MH 400 ppm), (48.40). The Plant Spread (cm) was found to be minimum (38.67) in the treatment T_0 with control.

This is probably due to which MH has been known as an effective chromosome-breaking agent in higher plants. MH on plant growth was mainly considered to result from the suppression of plant metabolism (inhibition of enzymic activity) and interference of the compound with plant hormones and growth regulators. MH acts as an inhibitor of the synthesis of nucleic acids and proteins. Plants can break down MH into several products, one of which, hydrazine, is a well-known mutagen and carcinogen.

3.4 Leaves per plant

Maximum number of leaves per plant (742.41) was observed in the treatment T_8 with (MH 300 ppm) followed by treatment T_9 with (MH 400 ppm), (711.8). The number of leaves per plant was found to be minimum (524.87) in the treatment T_0 with control.

Maleic hydrazide (MH) induced a high frequency of somatic mutations in leaves of marigold. MH has proved to be highly mutagenic and clastogenic but does not cause DNA damage in plants.

3.5 Days taken for first flower bud initiation

The number of days for flower bud initiation was found to be minimum (50.38) in the treatment T_2 with (CCC 1000 ppm) followed by treatment T_1 with (CCC 750 ppm) (52.90). The number of days for flower bud initiation were found to be maximum (57.94) in the treatment T_0 with control.

3.6 Days taken for first flowering after transplanting

The number of days for first flowering was found to be minimum (61.23) in the treatment T_2 with (CCC 1000 ppm) followed by treatment T_1 with (CCC 750 ppm) (63.75). The number of days for first flowering was found to be maximum (68.79) in the treatment T_0 with control.

This may be probably due to Cycocel slows down the cell division and cell elongation in meristematic tissues of shoot and regulate the plant height without formative effects and change the morphology and physiology of the plant. The

effect of decapitation of the main shoot subsequent to the emergence of floral buds resembles that of retardants indicating that the effect of the latter in flower promotion in this plant may be by virtue of their effect on cessation of apical dominance as a consequence of which reserve food materials may be channelled to axillary floral buds enabling them to develop into flowers. Similar results were also reported by Devedanam *et al.* (2007) and Ahmad *et al.* (2010) in Marigold [3].

3.7 Diameter of flower (cm)
The maximum diameter of flower (5.94 cm) was recorded in the treatment T_2 with (CCC 1000ppm) followed by treatment T_3 with (CCC 1250 ppm) (5.86cm). The minimum diameter of flower (5.04 cm) was found in the treatment T_0 with Control.

3.8 Stalk length of the flower (cm)
The maximum flower stalk length (8.84cm) was recorded in the treatment T_2 with (CCC 1000 ppm) followed by treatment T_9 with (MH 400 ppm) (8.06cm). The minimum flower stalk length (4.89cm) was found in the treatment T_0 with Control.

3.9 Number of flowers per plant
The maximum number of flowers per plant (24.12) were observed in treatment T_2 with (CCC 1000 ppm) followed by treatment T_3 with (CCC 1250 ppm) (24.07). The minimum number of flowers per plant (17.54) was found to be in treatment T_0 with control.

The effect of Cycocel reduces the number of short days required for flowering, increase the number of floral buds and flowers and delay their reversion to vegetative growth when transferred to non-inductive conditions. Similar results were also reported by Naidu *et al.* (2014) and Tyagi and Kumar (2006) in Marigold experiments [9, 11].

3.10 Flower yield per plant (g)
The maximum flower yield per plant (210.09 g) was observed in treatment T_2 with (CCC 1000 ppm) followed by treatment T_8 with (MH 300 ppm) (198.67g). The flower yield per plant was found to be minimum (103.59g) in treatment T_0 with control.

3.11 Flower yield per hectare (Tonnes)
The maximum flower yield (13.13 Tonne/ha) was found in T_2 with (CCC 1000 ppm) followed by treatment T_8 with (MH 300 ppm) (12.41Tonne /ha). The flower yield per hectare was found to be minimum (6.47Tonne /ha) was recorded in T_0 with control.

3.12 Weight of flowers (g)
The maximum weight of flower (12.67g) was recorded in treatment T_2 with (CCC 1000 ppm) followed by treatment T_3 with (CCC 1250 ppm) (12.54g). The weight of flower was found to be minimum (9.88g) in treatment T_0 with control.

3.13 Economics
The maximum gross return was recorded in T_2 (CCC 1000 ppm) (Rs. 2,62,600.00/ha) followed by T_8 (MH 300 ppm) (Rs. 2,48,200.00/ha). The minimum gross return (Rs. 1,29,400.00/ha) was recorded in T_0 with control.

The maximum net return was recorded in T_2 (CCC 1000 ppm) (Rs. 1,65,211.00/ha) followed by T_8 (MH 300 ppm) (Rs. 1,52,037.00/ha). The minimum net return (Rs. 37,237.00/ha) was recorded in T_0 with control.

Maximum Benefit: Cost ratio was recorded in T_2 (CCC 1000 ppm) (2.69) followed by T_8 (MH 300 ppm) (2.58) and the minimum Benefit: Cost Ratio (1.40) were recorded in T_0 with control.

The maximum yield of flower, gross return, net return and benefit: cost ratio was obtained with the treatment T_2 with (CCC 1000 ppm).

4. Conclusion
On the basis of present investigation, it is concluded that treatment T_2 with (CCC 1000 ppm) was found to be best treatment in terms of parameters studied. This treatment also showed maximum yield parameters in African marigold (*Tagetes erecta* L). cv. Pusa Basanti. The economics analysis reveals that maximum benefit cost ratio (1: 2.69), Net income, Gross income are maximum with this treatment.

Table 1: Effect of different plant growth retardants on plant growth, flowering and yield of African Marigold (*Tagetes erecta* L). cv. Pusa Basanti

Treatments		Height of plant (cm)	Number of branches per plant	Plant Spread (cm)	Leaves per plant	Days taken for first flower bud initiation	Days taken for first flowering after transplanting	Diameter of flower (cm)	Stalk length of the flower (cm)	Number of flowers per plant	Flower yield per plant (g)	Flower yield per hectare (Tonne)	Weight of flowers (g)	Net return (Rs./ha)	Benefit cost ratio
T_0	Control	73.27	6.91	38.67	524.87	57.94	68.79	5.04	4.89	17.54	103.59	6.47	9.88	37237	1.40
T_1	CCC (750 ppm)	48.80	6.83	40.47	667.56	52.90	63.75	5.60	6.93	22.6	186.09	11.63	11.56	136517	2.42
T_2	CCC (1000 ppm)	46.87	6.03	39.33	679.13	50.38	61.23	5.94	8.84	24.12	210.09	13.13	12.67	165211	2.69
T_3	CCC (1250 ppm)	46.73	6.89	39.40	659.67	53.98	64.83	5.86	7.80	24.07	195.51	12.21	12.54	145504	2.47
T_4	Ethephon (250 ppm)	53.53	6.60	40.53	585.67	53.11	63.96	5.51	6.70	19.4	122.14	7.63	10.72	57877	1.61
T_5	Ethephon (500 ppm)	57.87	6.72	44.00	585.93	54.11	64.96	5.15	7.06	22.6	119.79	7.48	10.67	52317	1.53
T_6	Ethephon (750 ppm)	55.73	6.65	41.20	654.87	55.94	66.79	5.18	5.89	20.6	136.67	8.54	11.09	70957	1.71
T_7	MH (200 ppm)	58.73	6.80	44.73	684.07	54.52	65.37	5.62	6.75	21.41	191.61	11.97	11.33	144571	2.52
T_8	MH (300 ppm)	57.73	6.92	48.60	742.41	56.72	67.57	5.66	7.30	23.01	198.67	12.41	11.73	152037	2.58
T_9	MH (400 ppm)	57.60	7.45	48.40	711.8	57.23	68.08	5.34	8.06	21.63	192.45	12.02	11.03	142904	2.46
F- test		S	S	S	S	S	S	S	S	S	S	S	S		
S. Ed. (±)		1.421	0.183	1.199	29.075	0.228	0.199	0.248	1.054	1.453	12.506	0.871	0.248		
C. D. (P = 0.05)		2.933	0.386	2.474	60.011	0.470	0.410	0.513	2.176	2.998	25.812	1.799	0.450		

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