

**IMPACT OF GROWTH RETARDANTS ON  
GROWTH AND FLORAL CHARACTERS OF  
CHRYSANTHEMUM POTMUMS  
(*Dendranthema grandiflora*)**

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**B.Sc. (Hons.) Hort.**

**MASTER OF SCIENCE IN HORTICULTURE  
(FLORICULTURE AND LANDSCAPE ARCHITECTURE)**



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**November, 2016**

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CHRYSANTHEMUM POTMUMS**

*(Dendranthema grandiflora)*

**BY**

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**B.Sc. (Hons.) Hort.**

**THESIS SUBMITTED TO SRI KONDA LAXMAN TELANGANA  
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**November, 2016**

## **CERTIFICATE**

**Mrs. B. SHAILAJA** has satisfactorily prosecuted the course of research and that the thesis entitled **“IMPACT OF GROWTH RETARDANTS ON GROWTH AND FLORAL CHARACTERS OF CHRYSANTHEMUM POTMUMS (*Dendranthema grandiflora*)”** submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination.

I certify that neither the thesis nor its part thereof has been previously submitted by her for a degree of any university.

**Date:**

**(DR. R.CHANDRASHEKHAR)**

**Place:** Rajendranagar, Hyderabad.

**Chairman**

# CERTIFICATE

This is to certify that the thesis entitled “**IMPACT OF GROWTH RETARDANTS ON GROWTH AND FLORAL CHARACTERS OF CHRYSANTHEMUM POTMUMS (*Dendranthema grandiflora*)**” submitted in partial fulfillment of the requirements for the degree of Master of Science in Horticulture (Floriculture and Landscape Architecture) of S.K.L Telangana State Horticultural University, Rajendranagar, Hyderabad is a record of the bonafide research work carried out by Mrs. **B. SHAILAJA** under our guidance and supervision.

No part of the thesis has been submitted by the student for any other degree or diploma. The published part and all assistance received during the course of the investigations have been duly acknowledged by the author of the thesis.

## **Thesis approved by the Student’s Advisory Committee**

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**Date of final viva – voce:**

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Date :

Place : Hyderabad

**(B.SHAILAJA)**

# DECLARATION

I, Mrs. BACHARAJA.SHAILAJA hereby declare that the thesis entitled **“Impact of growth retardants on growth and floral characters of Chrysanthemum potmums (*Dendranthema grandiflora*)”** submitted to the S.K.L Telangana State Horticultural University, Rajendranagar, Hyderabad for the degree of Master of Science in Horticulture (Floriculture and Landscape Architecture) is the result of original research work done by me. I declare that no material contained in the thesis has been published earlier in any manner.

**Date:**

**Name:** Bacharaja. Shailaja

**Place:** Rajendranagar

**ID. No:** RHM/14-18

## LIST OF SYMBOLS AND ABBREVIATIONS

<i>et al</i>	and others
%	Percent
G	Gram
@	At the rate
M	Metre
RH	Relative humidity
DAT	Days after transplantation
&	And
µg	Microgram
CD (P = 0.05%)	Critical Difference at 5 per cent level
Cm	Centimeter
CRD	Completely randomized design
PGR	Plant growth regulator
Hrs	Hours
a.i	Active ingredient
PBZ	Paclobutrazol
dm <sup>3</sup>	Cubic decimeter
Cvs	Cultivars
Kg	Kilogram
=	is equal to
Inch	Inches
ml	Milli litre
<	Less than

etc.	and so on
LD	Long day
SD	Short day
Var	Variety
FYM	Farm Yard Manure
L	Litre
Mg	Milligram
Mm	Millimetre
GA	Gibberilic acid
°C	Degree Celsius
SKLTSHU	Sri Konda Laxman Telangana State Horticultural University
Ppm	Parts per million
SEm ±	Standard error of mean ±
Fig	Figure
ETH	Ethephon
\	Per
B	Beta
m <sup>2</sup>	Metre square

Name of the author : **B.SHAILAJA**

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## **ABSTRACT**

The present investigation entitled “**Impact of growth retardants on growth and floral characters of chrysanthemum potmums (*Dendranthema grandiflora*)**” was carried out at floriculture research station, Rajendranagar, Hyderabad during the rabi season of 2015-2016. In the present investigation, an attempt has been made to determine the effect of different growth retardants on growth characters and floral characters of chrysanthemum potmums. The experiment was carried out in Completely Randomized Design.

In the present experiment, fourteen treatments were imposed with 3 replications. The treatments were T<sub>1</sub> (Paclobutrazol 30 ppm), T<sub>2</sub> (Paclobutrazol 60 ppm), T<sub>3</sub> (Paclobutrazol at 90 ppm), T<sub>4</sub> (Daminozide 500 ppm), T<sub>5</sub> (Daminozide 750 ppm), T<sub>6</sub> (Daminozide 1000 ppm), T<sub>7</sub> (Ethephon 250 ppm), T<sub>8</sub> (Ethephon 500 ppm), T<sub>9</sub> (Ethephon 750 ppm), T<sub>10</sub> (Ethephon 1000 ppm), T<sub>11</sub> (Uniconazole 4 ppm), T<sub>12</sub> (Uniconazole 8 ppm), T<sub>13</sub> (Uniconazole 16 ppm), T<sub>14</sub> (Control).

The data on vegetative growth was recorded on plant height, number of primary branches, plant spread at E-W and N-S, leaf length, leaf width, SCMR value, internodal length, diameter of the main stem and data regarding flowering was recorded on days to 1<sup>st</sup> flower bud appearance, days to 50% flowering, number of flower stems per plant, number of flowers per stem, number of flowers per plant, peduncle length, flower diameter, weight of the flower, duration of flowering, vase life. The results obtained were statistically analyzed in CRD. Salient features of the findings are summarized here under.

The results of experiment regarding vegetative parameters revealed that maximum reduction in the plant height (16.92 cm), plant spread E-W (19.42 cm) and N-S (17.75 cm), maximum SCMR value (74.86) were recorded with application of paclobutrazol at 90 ppm (T<sub>3</sub>) which was on par with paclobutrazol at 60 ppm (T<sub>2</sub>). Maximum diameter of main stem (7.73 mm), leaf length (6.26 cm), leaf width (4.41cm) were found in (T<sub>6</sub>) daminozide at 1000 ppm. Maximum number of primary branches (7.83) were found with (T<sub>1</sub>) paclobutrazol at 30 ppm and on par with (T<sub>9</sub>) ethephon at 750 ppm (7.75). Moderate reduction in plant height (24.25 cm), inter nodal length (0.86 cm), plant spread E-W (32.75cm), plant spread N-S (33.50 cm) were recorded with application of daminozide at 1000 ppm. Maximum reduction in internodal length (0.50 cm) was observed in paclobutrazol 60 ppm (T<sub>2</sub>) and on par with paclobutrazol at 30 ppm (0.54 cm).

With respect to floral parameters earliness in number of days to 1<sup>st</sup> floral bud appearance (75.17 days) was found with application of daminozide 1000 ppm followed by application of paclobutrazol 90 ppm and daminozide 750 ppm. Earliness in 50% flowering (100.00 days) and maximum duration of flowering (68.00), maximum number of flowers per stem (37.66) and number of flowers per plant (217.25) were found with (T<sub>6</sub>) daminozide at 1000 ppm which was on par with (T<sub>5</sub>) daminozide at 750 ppm. Maximum number of flower stems per plant (6.83) were observed in (T<sub>12</sub>) uniconazole at 8 ppm and was on par with (T<sub>11</sub>) uniconazole at 4 ppm (6.33). Maximum peduncle length (6.91 cm) was observed with (T<sub>4</sub>) daminozide at 500 ppm. Maximum diameter (3.98 cm) and weight of the flower (1.46 g) were observed in (T<sub>10</sub>) ethephon at 1000 ppm. Maximum vase life was found with (T<sub>4</sub>) daminozide at 500 ppm (16.33 days) which was on par with (T<sub>5</sub>) daminozide at 750 ppm (15.33 days).

The moderate growth reduction and increased chlorophyll in chrysanthemum potmums and earliness in flower bud appearance and 50% flowering, highest number of flowers per stem and number of flowers per plant, duration of flowering were observed with application of daminozide at 1000 ppm followed by application of daminozide at 750 ppm. These results were attributed to breakdown of gibberellin bio synthesis and suppression of vegetative growth which in turn promotes more buds to differentiate into flower buds with increased mobilization of photosynthates for flowering, which might have resulted in uniform growth and flowering producing higher quality of potted plants.

## **CHAPTER- I**

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### **INTRODUCTION**

# CHAPTER-I

## INTRODUCTION

Flowers are nature's gift to mankind and symbolize Purity, Peace, Love and Beauty. Among flowers, Chrysanthemum (*Dendranthema grandiflora*) occupy an important position in the world and ranks second among all flowers (Ganesh *et al.* 2014). This is popularly known as "Queen of the East", "Autumn queen" and belongs to the family Asteraceae. In India chrysanthemum occupy 2.18 lakh hectares of total area under floriculture with 14.21 lakh million tones production of loose flowers and 75,413 million numbers of cut flowers (Vaghasia and Polara, 2015). Chrysanthemum is commercially cultivated in Tamilnadu, Karnataka, Maharashtra, Andhra Pradesh and Telangana states.

Chrysanthemum (*Dendranthema grandiflora*) often called mums are semi hardy plants, mainly grown as ornamentals for pot culture (Pobudkiewicz, 2014) with flowers exhibiting wide range of colors. The dwarf and compact growing types (pot mums) are cultivated as pot plants for beautifying indoors and outdoors, whereas the erect and tall growing types (standards) are grown as cut flowers for making bouquets and vase decoration. Excellent range of color, form, long lasting quality of blooms and easy handling (do not require any staking) make them most popular among major pot crops. During the last decade or so, we have witnessed a significant change in our urban housing system and more people living in multistoried flats with little available space, and they primarily depend on potted plants for touch of green. So potmums production has become most profitable form of commercial chrysanthemum growing. As economy of space, time, material, exceptional hardy nature etc. made this style of growing very promising and pot mums are grown year round all over the world.

Now a days various chemicals are being tried for controlling growth and flowering of chrysanthemum with a view to have compact plants and also to

stretch out or retard the rate of plant growth (Vaghasia and Polara, 2015). Growth retardants treatments are increasingly studied with greater number of flowers and also to hasten or delay flowering according to the needs of growers in chrysanthemum (Datta *et al.* 1993). In recent years scientists have given due attention to the idea of regulating plant growth as third most important factor in improving the growth, yield and flower quality with the application of plant growth regulators in various ways. With the advancement of technology, the use of PGR's in modern horticulture and in industrially advanced countries is fast picking up. In fact, PGRs have become integral component of agro-technical procedures of cultivated ornamental crops.

Growth regulator is an organic compounds other than nutrients, which when used in minute quantities can either inhibit, stimulate, or alter growth. Plant growth retardants are synthetic compounds used to retard the shoot length of plants in a desired way without changing developmental patterns or evoke phytotoxic effects. This has been achieved not only by reducing cell elongation but also by lowering the rate of cell division and regulating the plant height physiologically (Rademacher, 2000). Most plant growth retardants inhibit the formation of growth-active gibberellins (GAs) and can thus be used to reduce unwanted shoot elongation (Singh, 2004). Plant growth retardant may also increase the number of lateral shoots, resulting in a larger number of inflorescences (Whealy *et al.* 1988).

The Plant growth retardants in ornamental horticulture are utilized commercially to produce compact, sturdy potted and bedding plants. This practice reduces the cost for pruning and allows obtaining a better ratio between vegetative growth and flower production, besides reducing the space in the greenhouse required for flower production and thereby improving market quality (Bekheta *et al.* 2008). Growth retardants are also used to enhance the green color of the foliage, strengthen the flower stems, stimulate flowering and promote resistance against environmental stresses (Kahar, 2008). They have also been noticed to increase the stress tolerance of plants during shipping, handling and retail marketing thereby improving the shelf life, aesthetic impression of the final

product, an important aspect in marketing practices (Latimer, 2001). As chrysanthemum is considered a long day for vegetative and short day for flowering, plant growth substances are found to counter the photoperiodic requirements of pot mums and maximize flower production as per market demands (Kazaz *et al.*2010)

Regulation of flowering in Chrysanthemum through growth retardants has immense practical value. In India use of PGR's in modern horticulture is well established fact (Singh *et al.* 2004) and lot of research has been geared towards the standardization of rate of application. However, in most cases these studies have not been extended to large scale and application rates for most economical yields are not yet defined. Hence the effect of different levels of growth retardants on pot mums is studied with the following objectives.

**Objectives:**

- To study the effect of different growth retardants on growth characters of Chrysanthemum pot mums.
- To study the impact of different concentrations of growth retardants on floral characters of the crop.

## **CHAPTER-II**

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# **REVIEW OF LITERATURE**

## CHAPTER II

# REVIEW OF LITERATURE

Chrysanthemum, the golden flower is derived from two Greek words (*Chryos* meaning golden and *Anthus* meaning flower), is one of the most beautiful and oldest flowering plants. Chrysanthemum botanically known as (*Dendranthema grandiflora*) belongs to the family Asteraceae, is believed to have originated from China. Chrysanthemum is one of the most important ornamental crops around the world, and it is grown both as cut flower and pot plant (Van Der Ploeg and Heuvelink, 2006). In India, it has been recognized as one of the five commercially potential flower crops. It is short-day plant with a critical day length of approximately 13.5 hrs. (Post, 1931).

A major problem with chrysanthemum grown as pot plant is plant height greater than desired and an irregular plant habit. The fastest and cheapest way to improve compactness and to reduce the height of chrysanthemums is application of growth retardants. Many researchers have shown that there is great variation in sensitivity of chrysanthemum cultivars to application of growth retardants. Due to these different responses of chrysanthemums to growth retardant treatment, doses of these compounds, required to inhibit stem elongation, should be determined individually for each variety.

Chemical growth retardants are the most commonly used and commercially important plant growth regulators (PGRs) in floriculture, because of their specific properties in regulating shoot growth and thus reducing plant height. (Grossman, 1990). When applied in appropriate concentrations, growth retardants modify plant architecture in a typical fashion (Fletcher *et al.* 2000).

Growth retardants have an inhibiting effect on cell division and enlargement of cells in plants and decrease the internodes length, eliminate the epical dominance and therefore they are widely used for height control in floriculture (Pasian, 1999). Height control in plants has an important role in

avoiding unacceptably tall plants that require more space, labor and higher transport costs, as well as improve yield and quality (Hayashi *et al.* 2001).

Some of the most important factors concerning plant growth retardants are type, time, number, application method and concentration of growth retardant. (Cramer and Bridgen, 1998). Soil drenches are usually more precise, more predictable (Menhennett and Hanks, 1983), less phytotoxic and less dependent on prevailing environment factors than spray application. The large volume of chemicals needed and the labor required are disadvantages. (Tija and Sheehan, 1986).

In recent years various chemicals are being tried for controlling growth and flowering of chrysanthemum with a view to have compact plants and also to retard the rate of plant growth. Exogenously applied growth substances produce their effect through the alternation in endogenous hormones, thus modifying the growth and development of plants. These substances modify the plants physiological processes within the plant and usually affect Gibberellins which are responsible for shoot elongation (Rademacher, 1991). The effects of stem elongation cannot be reversed; however, the application of growth retardants can slow down the process.

For the highest efficacy, growth retardants require application prior to or during the rapid growth phase to reduce internode elongation (Dole and Wilkins, 2004). However, the optimal rate of application and sensitivity of the plants to each retardant may vary greatly from one species to another. Application of these retardants requires great caution to eliminate the possibility of crop loss or prolonged production time (Wang and Blessington, 1990).

Keeping in view the objectives of the present investigation, the work done so far on the above aspects, literature pertaining to Chrysanthemum and other horticultural and field crops has been reviewed under the following headings:

## 2.1 Effect of Growth Retardants on growth & flowering

### 2.1.1 Effect of Paclobutrazol

2.1.2 Effect of Daminozide

2.1.3 Effect of Ethephon

2.1.4 Effect of Uniconazole

## **2.1 EFFECT OF GROWTH RETARDANTS ON GROWTH AND FLOWERING**

### **2.1.1 Effect of Paclobutrazol**

Paclobutrazol is one of the most important triazolic compounds which are used as growth retardants in some crops. Chemically paclobutrazol is (2S, 3S) -1 (4-chlorophenyl)-4, 4-dimethyl-2-(1,2,4-triazol-1-yl) pentan-(3-ol). It is available in different trade names such as Bonzi, Clipper, Cultar and Parley.

The most obvious plant growth response of paclobutrazol is reduction of stem elongation and reduced plant height. It is known to reduce the plant height by interfering with gibberellins biosynthesis, hence termed as anti-gibberellin (Hedden, 1997). Paclobutrazol treated plants appear darker green than the untreated control plants. In most cases, thick dark green appearance of leaves is correlated with increased chlorophyll content Sankhla *et al.* (1985).

Paclobutrazol is most widely used growth retardant in ornamental crops and widely acclaimed as a tool to increase the productivity. Paclobutrazol is known to enhance the yield at the cost of vegetative growth. Since the work carried out on paclobutrazol is scanty in Chrysanthemum, the responses elicited by paclobutrazol in other floricultural crops have been reviewed.

#### **2.1.1.1 Effect of Paclobutrazol on growth parameters**

Barrett and Nell (1983) reported that paclobutrazol at 5 and 10 mg/ plant drench and 2000 ppm spray applications reduced shoot elongation in *Ficus bejamina* and internodal elongation in pruned plants (36%) and unpruned plants (25%). This resulted in stiff branches on plants that did not exhibit typical weeping habit of untreated plants.

Menhenett (1984) reported that Paclobutrazol drench at 30 to 50 mg a.i./l is very effective in controlling stem extension in the pot Chrysanthemum

(*Chrysanthemum morifolium*) 'Bright Golden Anne'. In comparison paclobutrazol needed less by 50 to 100 times concentration of foliar spray of daminozide to induce equal dwarfing effect. Lateral stem length was little higher with foliar sprays.

Barrett and Nell (1986) reported that spray application of paclobutrazol at 25 and 50 ppm and drench at 0.25 and 0.5 mg/ pot 2 weeks after transplanting in *Chrysanthemum morifolium* 'Bright golden Anne' and in *Exacum affine* Balf.f. 'Blue Champion' caused moderate reduction in plant height in summer. Increased concentrations generally resulted in shorter plants (21 and 27.6 cm) compared to control.

Mansour and Poole (1987) reported that paclobutrazol applications at 0.25 and 0.5 mg a.i / pot caused highly significant reduction (35%) in plant height of *Peparomia obtusifolia* whereas leaf area, chlorophyll content were not affected. Leaf area was reduced in *Dieffenbachia maculata* and the root growth was retarded in both species. The vine growth was not affected when applied to *Philodendron scandens oxycardium*.

Anderson and Hartley (1990) reported that three soil applications of paclobutrazol at 11ppm reduced plant height to a 20 cm in Satin flower (*Clarkia amoena*) during the fall and winter (ambient light conditions). Under 24 hr. supplemental light conditions application at 20 ppm significantly reduced plant height five weeks after transplanting.

Latimer (1991) reported that application of paclobutrazol 40 and 90 ppm 5 weeks after transplantation exhibited reduction in plant height in *Zinnia elegance*. Stem elongation of *Impatiens walleranaw* was moderately controlled by paclobutrazol 20 ppm applied 7 weeks after transplantation. Shoot dry weight and stem elongation in *Tagetes erecta* is reduced by paclobutrazol 40 ppm in the greenhouse.

Gilbertz (1992) reported that spray application of paclobutrazol 30 and 60 mg/lin *Dendranthema grandiflora*(2 weeks after pinching) significantly reduced the plant height 27% and 40% respectively relative to controls when applied at

pinching, but the same rates only caused 3% and 7% reductions when applied at 4 weeks of pinching. Shoot dry weight was limited which was attributed to less stem length.

Eckeret *et al.* (1992) reported that substrate drench of paclobutrazol 0.5 mg and 2mg/pot applied 20 days after potting altered the entire morphology in treated plants of *Matthiola incana* to a thicker and more compact plants and concluded that the medium drench of 0.5 mg/pot produce more commercially desirable plants. Increasing the dose of paclobutrazol reduced the stem length in cultivar 'Lavender' but not of cultivar 'Midget red'.

Burrows *et al.* (1992) reported that Paclobutrazol drench at 1.0 and 5.0 mg/50 ml resulted in shorter stems with reduced stem diameter (50%) and increased root diameter with an unusual segmented appearance due to increased diameter of cortical cells in *Chrysanthemum* cv. 'Lillian Hoek'. Increased leaf thickness and dark green colour was observed due to an additional layer of palisade mesophyll. Leaves from PBZ treated plants are smaller than control plants.

Wilfert and Barrett (1994) reported that foliar spray of paclobutrazol in potted Azaleas (*Rhododendron obtusum* planch.) at 400ppm applied 4 to 5 weeks after pinching yielded plants shorter and not as wide as control (34.0 and 73.5 cm) by reducing plant height (34.5 cm) and diameter (44.5 cm). Bypass shoot development was arrested with PBZ sprayed at 200 ppm and drenches at 10 to 15ppm. Plants sprayed twice at 400ppm were shorter than treated once at 100ppm.

Gent (1997) reported that application of Paclobutrazol at 5 to 20 mg /plant in four cultivars of *Rhododendron* Roseum Elegance reduced stem elongation (50%) equally in the year of application. In the next year stem elongation was inhibited (12%) by higher dose (20 mg /plant) in *Kalmia* Yankee Doodle and leaves were smaller in size compared to control. Stem diameter was unaffected and no phytotoxicity was observed.

Kim *et al.* (1998) reported that two spray applications of Paclobutrazol 50mg/l in early and late spring in Dutch grown Bleeding Heart (*Dicentra spectabilis*) reduced total plant height effectively up to 58%. Chlorophyll content was increased producing deep green leaf colour. Total number of shoots, stem strength was not significantly affected by PGR.

Burnett *et al.* (2000) reported that application of Paclobutrazol at 66 and 99 ppm retarded growth of *Achillea* cv. 'Coronation gold' and *Gaura lindheimeri* by 15% and 31% in both the years of experiment. Application at first flower decreased height by 17% to 16% when marketable at 60 DAT.

Banon *et al.* (2001) reported that paclobutrazol 5 and 20 mg / plant in *Nerium oleander* inhibited plant growth (22-49%) and plant height, intermodal length (31 to 52%) and aerial part dry weight and leaf blade area (41 to 49%), stem diameter (6 to 24%) were significantly reduced. Number of shoots (3.8) and chlorophyll content (23.4 – 38.9%) were increased.

Arnold and McDonald (2001) reported that paclobutrazol substrate drench (40 and 80 mg/l), reduced the internode extension in Blue Plumbago producing a more compact canopy. Increase in growth in response to lower concentrations of PBZ (40 mg/l) drenches was observed in 1<sup>st</sup> year landscape trials whereas higher concentrations of PBZ (80 mg/l) tended to limit growth excessively and cause 50% reduction in plant indices. Plants treated with 20 mg/l appeared more uniform than the controls. Foliar spray application at 400 mg/l reduced the plant growth index.

Laurence *et al.* (2002) reported that drench with paclobutrazol 2 to 4 mg/pot (a.i.) resulted in shorter plants by effectively reducing plant height of Sunflower (*Helianthus annuus*) incv. 'Pacino' (20.4 cm) and in 'Teddy bear' (14.3 cm) compared to control (36.6 cm).

Chenet *et al.* (2002) reported that foliar application of paclobutrazol at 15 and 50, 100 ppm resulted in compact plants in *Gynura aurantiaca* with shorter stems and internode lengths. Leaf sizes became smaller than control. Number of

shoots was not affected significantly. Plants were with overall quality rating of 3 (fair), may be salable if bud and flower occurrence is not a concern.

Warner and Erwin (2003) reported that one-time spray application of paclobutrazol (20 and 40 mg/l) reduced stem elongation of *Hibiscus radiatus* and *Hibiscus trionum* at 14 days after application compared to untreated plants. Application in *Hibiscus rosa-sinensis* resulted in darker green colour in leaves and 25 mg/l PBZ reduced plant height by 25% compared to untreated plants, but multiple applications were necessary for long term height control.

Banon *et al.* (2003) observed a significant reduction in plant height with application of paclobutrazol 0.2, 0.3 and 0.4 mg/pot and as a single soil drench (25 DAT) in *Reichardia tingitana* has significantly reduced plant height with all doses by 73.1%. Plant width and leaf blade area (61.55%) were reduced. Chlorophyll content was increased resulting in darkening of the leaves.

Khassawneh *et al.* (2005) reported that the drench application of paclobutrazol 0.5 mg/l in black Iris (*Iris nigricans* Dinsm.) resulted reduction in plant height and produced suitable pot plants whereas paclobutrazol 500 mg/l spray application resulted in undesirable control of plant height and reduction in stalk height and weight.

Christiana *et al.* (2005) reported that spray application of paclobutrazol drench (0.5 and 1.0 mg a.i/pot) significantly reduced plant height (36.99 cm) and side branches length (26.95 cm) in *Zinnia elegans* which is related to shorter internode (5.00 cm) elongation. Treated plants resulted in increased chlorophyll biosynthesis and leaf mass ratio, showed darker green leaves. Leaf area and plant spread diameter were reduced.

Kruget *et al.* (2006) reported that substrate drench of 0.25 to 4 mg/ pot a.i paclobutrazol controlled the stem stretch during postharvest evaluation resulting in 19% shorter plants (26.1 cm) in Sweetness narcissus (*Narcissus pseudo narcissus*) than control and did not control height during greenhouse forcing of 'Tete a Tete' cultivar at any concentrations trialed. Preplant bulb soaks at 75 mg/l controlled postharvest stem stretch in 'Dutch master' cultivar.

Currey *et al.*(2010) reported that application of Paclobutrazol at 2.0-4.0 ppm final stem length (24.9 and 20.9cm) of Calibrachoa (*Calibrachoa\*hybrid*) and plant height (11.9 to 16.7 cm shorter) of Pansy (*Viola wittrockiana*) after planting in containers filled with substrate containing 80% peat and 20% parboiled Rice Hulls. Based on these results it is concluded that Rice Hulls did not reduce PGR drench efficacy on plants.

Ozgur (2011) reported that the seeds soaked for 24 hours in paclobutrazol of 500 and 1000 mg/l solution reduced seedling height (63.4% to 74.9%) and epicotyl diameters, leaf area, leaf and stem dry weight of Cucumber compared to control.

Nazarudin (2012) reported that soil drenching of paclobutrazol (0.25g/l) significantly reduced the plant height (15.6%) and leaf area (59.6%) in *Hibiscus rosa-sinensis*. Chlorophyll content was significantly higher in PBZ-treated plants (30.6%) made the leaves appear greener.

Currey and Erwin (2012) reported that drench application of paclobutrazol (10-40 ppm) on 11 *Kalanchoe* species (applied 2 weeks after pinching) inhibited stem elongation by 2.0 cm (17% less) most effectively in all species compared with untreated plants which is attributed to PGR solution being applied to substrate surface and subsequent root uptake. In *Kalanchoe pumilastem* suppression was 2.5 cm (39%) and in *kalanchoe streptantha* was 2.0 cm (24%) in treated plants.

Dorajeerao (2012) reported paclobutrazol foliar application at 80 ppm (65 DAT) concentrations in kharif and rabi seasons recorded significant reduction in plant height (85.15 cm) and leaf area (735.5 cm<sup>2</sup>) in garland Chrysanthemum (*Chrysanthemum coronarium*). Total dry matter accumulation (15.08 g/plant) and number of branches was significantly increased compared to control.

Christiana da Silva *et al.* (2014) reported that paclobutrazol applied at 5 and 20 mg/l in *Arundina graminifolia* was effective in controlling plant height (33 cm). Higher concentrations (10 and 20 mg/l) proved to be toxic to the plants

causing death to the new shoots, deformation of buds and delayed bud formation. At lower concentrations offered a viable means for height control.

Vaghasia and Polara (2015) reported that paclobutrazol at 0.4 ml/l and 0.5 ml/l spray application on Chrysanthemum (*Dendranthema grandiflora*) resulted in significant growth reduction in plants compared to control. There was increase in fresh and dry weight of the plants and number of main and secondary branches and plant spread in both the directions at 90 DAT.

#### **2.1.1.2 Effect of Paclobutrazol on flowering**

Eckeret *et al.* (1992) reported that substrate drench of paclobutrazol 0.5 and 2 mg/pot reduced inflorescence length of *Matthiola incana* cultivar 'Lavender'. The time of potting to flowering of 'Lavender' was prolonged by increasing the level of paclobutrazol whereas time of flowering of 'Midget-Red' was not influenced.

Wang and Hsu (1994) reported that seedling dip of paclobutrazol (50 and 200 mg/l) caused delay in inflorescence emergence and bloom date in *Phalaenopsis* Orchids. Foliar spray (125 to 500 mg/l) treatments before inflorescence emergence (4 weeks after planting) restricted stalk elongation (17% shorter) and internode length between the two flowers. Flower size, flower count and stalk diameter were unaffected by the treatments.

Burnett *et al.* (2000) reported application of Paclobutrazol at 66 and 99 ppm accelerated flowering of *Achillea* cv. 'Coronation gold' and *Gaura lindheimeri* in the second year of experiment. Treated plants flowered 3 to 6 days earlier than control. Reproductive buds were 26 – 55% more developed than untreated plants.

Starman and Williams (2000) reported that the paclobutrazol drench at 4 – 8 mg/l and of *Scaevola aemula* reduced flower stem number and length. There is no reduction in number of flowers per stem which gave floriferous, compact round clusters of the flowers. Foliar sprays at 40 and 80 mg/l did not affect most of the flowering variables.

Banon *et al.* (2003) reported that application of paclobutrazol 0.2, 0.3 and 0.4 mg/pot and as a single soil drench (25 DAT) in *Reichardia tingitan* reduced the number of flower buds (16.8 to 21.6 buds per plant). Doses 0.4 mg increased time taken to flowering. Flower size was not affected to any significant degree. The number of flower stems per plant and flower stem diameter (52.1%) was highly and significantly decreased.

Haque *et al.* (2007) reported that paclobutrazol application at 80 and 160 mg/l increased pyrethrins level (21%), single flower weight and decreased flower yield in *Chrysanthemum cinerariaefolium*.

Dorajeerao (2012) reported paclobutrazol foliar application at 40,60 and 80 ppm concentrations in kharif , rabi seasons recorded a higher number of flowers per plant than control in garland Chrysanthemum (*Chrysanthemum coronarium*). Increase in concentrations , reduced the number of flowers per plant. There was an increase in the flower yield per plant by the foliar application than untreated plants.

Nazrudin (2012) reported that soil drenching of paclobutrazol (0.25g/l) at 75 days after application, significantly increased number of blooms (39.5%), induced uniform flowering in *Hibiscus rosa- sinensis* and delayed flowering by 26 days. Significant positive relationship found between number of blooms and total root length.

Vaghasia and Polara (2015) reported that Paclobutrazol at 0.4 ml/l and 0.5 ml/l spray application on Chrysanthemum (*Dendranthema grandiflora*) reduced the days to first flower bud appearance, first flowering and days to 50% flowering at 30 DAT. Number of flowers per plant was increased which attributed to more number of branches accumulated more carbohydrates used to increase flower yield.

#### **2.1.1.3 Effect of Paclobutrazol on vasselife**

Jones *et al.* (1998) reported that paclobutrazol (Cultar® at 5mg a.i.) application to Sturt's Desert Pea plants (*Swainsona formosa* formerly *Clianthus*

*formosus*) at 4 and 8 weeks post germination, marginally reduced the vase life of flowers which is attributed to possible increase in photosynthetic competence.

Chun Leil *et al.* (2011) reported that the application of paclobutrazol [(PP33) prolonged the vase life in Cut *Chrysanthemum* cultivar 'Xiahuang', delay senescence and increased the fresh mass (29.11%) and declined the water stress and thus the vase life could be prolonged by about 15.2 days when compared to control.

### **2.1.2 Effect of Daminozide**

Daminozide (butanedioic acid mono 2, 2-dimethyl hydrazide) considered as one of the most systematic growth retardants, and it has various effects in plants. It belongs to the group succinic acid, unlike other growth retardants, contains no benzene ring, quaternary ammonium or phosphonium cation, nor any substituents that are small, nucleophilic, containing a C-C-C-N system (Sheibany *et al.* 2007). It is available in different trade names such as ALAR, B-9.

Read and Hoysler (1971) found that the obvious plant growth response of ALAR is the reduction of plant stature by reducing internodes length as a result of compact cells. In some cases, foliage turns deeper green associated with greater stem strength and increased number of flowers.

#### **2.1.2.1 Effect of Daminozide on growth parameters**

Barrett and Nell (1986) reported that daminozide spray applied at 2500 ppm 2 weeks after transplanting in *Chrysanthemum morifolium* 'Bright golden Anne' and applied twice or three times at 7 days' interval in *Exacum affine* Balf.f. 'Blue champion' and caused moderate reduction in plant height (35.6 and 19cm) compared to non-treated plants.

Wilfert (1991) reported that two spray applications of daminozide (2500 ppm) decreased the plant height and plant diameter of *Chrysanthemum* (*Dendranthema grandiflora*) and prevented the excessive internodal elongation. Three applications of the chemical at 2500 ppm produced shorter plants in 7 cultivars.

Wilfert and Barrett (1994) reported that foliar spray of daminozide in potted Azaleas (*Rhododendron obtusum* planch.) at 2500ppm (4 to 5 weeks after pinching) retarded plant height (24 cm) and plant diameter (45.5 mm) than control (34.0 and 73.5 cm). Bypass shoot development was arrested in treated plants.

Schuch (1994) reported that foliar spray of daminozide at 1000 mg/l and 2000 mg/l had no effect on final plant height or width, but reduced stem dry weight in *Dendranthema grandiflora*. Leaf area was increased in treated plants and transpiration was unaffected.

Cramer and Bridgen (1998) reported that daminozide spray 2500 and 5000 mg/l applied at 2 weeks post pinch on *Mussaenda* 'Queen Sirikit' reduced the plant height and produced most attractive potted plants. Higher concentrations or additional applications excessively reduced the plant height.

Kim *et al.* (1998) reported that spray application of two sprays of daminozide at 3000mg/l reduced total plant height effectively up to 58% compared to control in Dutch grown Bleeding Heart (*Dicentra spectabilis*). Chlorophyll content was increased producing deep green leaf colour. Plant quality was significantly increased by the daminozide spray (3000 mg/l) and PBZ (2.0 mg a.i) combination, but plant strength was not affected. No phytotoxicity of leaves was reported by the treatment.

Burnett *et al.* (2000) reported application of B-9 at 2500ppm and 5000 ppm provided growth suppression of *Achillea* cv. 'Coronation gold' and *Gaura lindheimeri* 'Corrie's gold' by 9% from 28 DAT. When plants were pruned just prior to treatment, height at most effective concentration of 7500 ppm was reduced by 33% compared to untreated plants.

Zidovec *et al.* (2001) reported that application of daminozide of 0.1 and 0.2% solution after pinching reduced the plant height (27.5%) of Lavender (*Lavandula vera*) compared to plants that were not pinched. Plants treated with daminozide solution of lower concentration had the smallest number of lateral

branches (2.2% less). Regardless of the treatment, pinched plants had a smaller number of lateral branches (2.33% less) compared to plants that were not pinched.

Chen *et al.* (2002) reported that B-9 treated plants produced comparable numbers of lateral shoots to the control plants. Stem lengths decreased linearly resulting in compact plants in *Gynura aurantiaca*. Average internode lengths and leaf lengths and width decreased linearly. Overall quality rating of plants rated at 3 = fair suggesting that the plants could be salable.

Karlovic *et al.*, (2004) observed that daminozide of 3000 mg/l was most efficient concentration for height regulation of *Chrysanthemum* cultivar 'Revert' with 12.5% reduction in height in the first year and that of 2000 mg/l in the second trial year and there was no significant difference between the application of 2000 and 3000 ppm concentrations. However lower concentrations were recommended in height regulation for environmental reasons.

Sheibany *et al.* (2007) found that Alar applied at three concentrations of 1250, 2500, 5000 ppm twice (repeated 2 weeks after the first application) as foliar spray in *Chrysanthemum morifolium* reduced shoot length one week after transplanting. Treated plants were significantly shorter with less intermodal length and increase in stem diameter compared to control. The short foliage stature was proportional with the concentration applied, and had no effect on apical dominance.

Kofidis and Ginnakoulou (2007) reported that daminozide applied at 500 and 1000 mg/l resulted in 25% shorter plants of *Coriandrum sativum* than controls and reduced stem internodal length. The leaf thickness and stem diameter (17-37%) was significantly increased. Chlorophyll content of treated plants was increased by 16% resulting in dark green leaves. Essential oil and fruit yields were declined.

Lorena and Carolina (2010) reported that the application of daminozide twice (15 and 30 days after sowing) at 6000 mg/l, three times at 4000 mg/l decreased the final plant height (<2 meters) by reducing the unwanted

longitudinal growth of Sunflower (*Helianthus Annuus*) adequate as cut flower inside the green house, but not small enough to grow it as a potted plant. Head diameter was not decreased attending the consumer preference of big Sunflower.

Kazaz *et al.* (2010) reported that day length (SD conditions) and daminozide (3000 mg/l) significantly reduced the stem length (79.21 cm) compared to control (89.73 cm) in *Chrysanthemum morifolium*. Stem diameter, stem fresh weight (128.12 g/stem), dry matter content (19.44 %) of the plants, Chlorophyll a and b were significantly increased (11.5 µg/mg) in treated plants under LD conditions.

Zakrzewski and Anita Schroeter (2011) reported that the application of Metaconazole once (300 mg/ dm<sup>3</sup>) and daminozide applied twice of 2,550 mg/dm<sup>3</sup> in autumn growing period reduced the height (7.0 cm) as well as number of shoots (6.2) of *Chrysanthemum grandiflorum* compared to control (22.6 cm and 8.3 numbers respectively). Plant width was decreased in spring and summer terms.

Ahmad Bhatet *al.* (2011) studied effect of foliar spray of cycocel and B-9 on *Erysimum marshalii* and reported that plant height was not affected by B-9 at 500,1000 and 1500 mg/l application. Number of laterals was slightly decreased and leaf area was significantly decreased by B-9 application. The fresh and dry mass of leaves, roots and stem was decreased.

Kazemi *et al.* (2014) reported that application of daminozide at 3000 mg/l and 4500 mg/l limited the stem elongation and reduced the plant height (24 cm) of Marigold (*Calendula Officinalis*) 5-6 weeks after potting. Plant fresh weight, dry matter, essential oil and chlorophyll content were significantly increased. Largest number of leaf was obtained in 3000 mg/l application.

Ganesh (2014) reported that single application of daminozide at 1500 and 2500 ppm at (7 and 14 days after darkening) reduced the plant height (34.33cm.) of *Chrysanthemum* Var. Punch at considerable level. Leaf area, cut steam girth (3.24 cm), steam fresh weight (68 gm) and chlorophyll content, cut stem yield (77.34 stems/m<sup>2</sup>) and pedicel length (5.87 cm), soluble protein content

(80.66mg/g) were increased.

### 2.1.2.2 Effect of Daminozide on flowering

Hicklenton *et al.* (1990) reported that daminozide spray (0.014 and 14 mg a.i / pot) reduced flower area, flower dry weight in three cultivars of Chrysanthemum (*Dendranthema grandiflora* Tzvelev.). Flowering was delayed by 2-4 days in each cultivar by post-plant treatment of daminozide spray applications.

Wilfert and Barrett (1994) reported that foliar spray of Daminozide twice in potted Azaleas (*Rhododendron obtusum* planch.) at 2500ppm (4 to 5 weeks after pinching) increased number of days to flower with both treatments and there was increase in multiple floral buds per lateral, made plants showier.

Wang and Hsu (1994) reported that seedling dip of daminozide (2500 and 5000 mg/l) in *Phalaenopsis* Orchids delayed flowering by 5 to 13 days, whereas foliar application had no effect. Flower size and flower count and stalk thickness were unaffected. Foliarly applied daminozide increased stalk length than non-treated plants.

Kim *et al.* (1998) reported that spray application of two sprays of daminozide at 3000mg/l in Dutch grown Bleeding Heart (*Dicentra spectabilis*) delayed flowering by 4 days. No significant effect found on number of flowering shoots. Total inflorescence height reduced 2 weeks after treatment.

Laurence *et al.* (2002) reported that B-9 at 8000 ppm spray application in Sunflower (*Helianthus annuus*) cv. 'Pacino' caused delay in flowering by 1 to 4 days and had greater number of days to anthesis compared to control. There was decrease in flower diameter (by 1.9 to 2.1 cm) and postharvest life (10 days) compared to untreated controls.

Krause (2003) reported application of B-9 sprayed twice (second spray applied 10 days later) at 1275 mg/l (0.15%) stimulated flowering in *Tagetes patula* and *Petunia hybrida*. Number of inflorescence buds is increased and there was increase in decorative value.

Christiana *et al.* (2005) reported that spray application of daminozide (2.5 and 3.75 g/l) in *Zinnia elegans* promoted flowering and increased inflorescence dry mass, reduced inflorescence diameter with 5.0 g/l application. There were no apparent effects on inflorescence color and shape. Inflorescence harvest index was increased (0.22g) with increasing concentrations. Daminozide promoted the translocation of photosynthates to the inflorescences thus improved plant quality and delayed flowering time which is attributed to restriction in gibberellins.

Kazaz *et al.* (2010) reported that day length (SD conditions) and daminozide (3000 mg/l) significantly had a higher number of flowers per stem (14.11 flowers / stem) in *Chrysanthemum morifolium* whereas 11.17 flowers per stem in untreated plants. Days to flower were slightly delayed (0.58 days) and there was increase of yield and compact, uniform quality of flowers with both under SD conditions and the treatment application.

Zakrzewski and Anita Schroeter (2011) reported that the application of Metaconazole once (300 mg dm<sup>3</sup>) and daminozide applied twice of 2,550 mg/dm<sup>3</sup> in summer growing period of *Chrysanthemum grandiflorum* produced greatest number of flower heads (20 flower heads). Flowering was delayed between 3 to 8 days in treated cultivars 'Paloma' and 'Hellen'. In autumn treated plants produced smaller number of inflorescences and reduction in flower head diameter.

Ahmad Bhat *et al.* (2011) studied the effect of foliar spray of cycocel and B-9 on *Erysimum marshalii* and reported that B-9 at 500, 1000 and 1500 mg/l application slightly decreased the flowering yield and flower diameter compared to controls. The number of flowers was decreased and number of floral heads was increased than control.

Davood *et al.* (2012) reported that number of flowers was strongly influenced by interaction effect of CCC and B-9 in *Calendula officinalis*. Application of B-9 1500 mg/l + CCC 500 mg/l produced the highest number of flowers per plant (3.33) that is 150% more than that of control. Highest amount of essential oils per 100g dried flower (0.159 ml) was observed with application of B-9 at 4500 mg/l and flower quality was increased in treated plants than

control. Flower fresh weight was increased in line with increasing concentrations. Days to flowering were delayed under all concentrations.

Kazemi *et al.* (2014) reported that application of daminozide at 1500 mg/l and 4500 mg/l resulted in maximum number (4.66/plant) of flowers than control in Pot Marigold (*Calendula Officinalis*). Petal essential oil (0.15 ml/100g FW), carotenoid (8.22 mg/l) content was increased. Lowest time of flowering (98.00) days were related to 1500 ppm application when compared to control (122.60 days).

Ganesh (2014) reported that single spray application of daminozide at 2500 ppm in *Chrysanthemum* Var. Punch significantly increased the number of flowers per spray. Number of days to flowering (44.72) and days to harvest (81.33days) was reduced compared to control. There was marketable reduction (67.07 and 79.07 cm) in flower stalk length.

### **2.1.2.3 Effect of Daminozide on vase life**

Kahar (2008) reported that the increased concentration from 0 to 5000 mg/l of daminozide in *Chrysanthemum* 'Regan Sunny' doubled the vase life with one application, but the reverse response was found with two and three applications. Single application with the concentrations of 1,250 and 2,500 mg L-1 is recommended for production of good spray form and long vase life for chrysanthemum.

Patil (2013) reported that the application of daminozide at 1500 ppm enhanced the vase life by 2.60 days in China aster (*Callistphus Chinensis*) compared to untreated (control) plants which is attributed to increased chlorophyll content of leaves and ultimately resulting in increase in vase life of flowers in both varieties Phule Ganesh White and Phule Ganesh Violet.

Ganesh (2014) reported that single spray application of daminozide at 2500 ppm *Chrysanthemum* var. Punch significantly increased vase life (12.50 days) at 7 days after darkening than control (5.27 days) which is attributed to internal physiological status of the cut stems delaying early onset of the

senescence. Improvement in water relations, hydraulic conductance, carbohydrates prevented vascular blockage and increased the vase life.

### **2.1.3 Effect of Ethephon**

Ethephon- [(2-Chloroethyl) Phosphonic acid] which is the class of organo phosphorous is known as ethylene generator and plant growth regulator. Its use varies with plant species, chemical concentration, and time of application. Ethephon regulates phases of plant growth and development by application to various growth sites. Although it is used as foliar spray, effectiveness of drench has not been widely investigated. Ethephon's mode of action acts via liberation of ethylene, which is absorbed by the plant and interferes in the growth process. The different trade names by which ethephon is commonly known as are Floral, Arvest and Bromeflor.

A foliar spray of floral will increase the number of lateral branches of many ornamental plant species, reduce total plant height, inhibit stem elongation of potted plant, reduce the stem topple at the time of full flower. Endogenous and external ethylene is the main factor of reducing post-production life and promoting flower, foliage abscission and abort flowers of many ornamentals.

#### **2.1.3.1 Effect of Ethephon on growth parameters**

Banon *et al.* (2001) reported that application of ethephon 0.5 to 5 g / plant in *Nerium oleander* inhibited plant growth (15 to 48%). Number of branches significantly increased from 1.8 to 3.8. Internodal length (12 and 50.8%) and leaf blade area (46 to 71%), dry weight of aerial part (15 to 58%) were reduced significantly compared with control. Only 5g dose reduced chlorophyll content.

Chenet *al.* (2002) reported that ethephon treated plants at 250 and 500, 1000 ppm produced significantly more lateral shoots resulting in compact plants in *Gynura aurantiaca* with shorter stems and internode lengths without reduction in leaf sizes compared to control.

Banon *et al.* (2003) reported that the application of ethephon 100 mg/plant significantly reduced plant height by 50.3% in *Reichardia tingitana*. Plant width and aerial part dry weight (87.1%), leaf blade area (88.6%) were reduced. Relative chlorophyll content (36.4%) was reduced.

Kruget *et al.* (2006) reported that foliar spray of ethephon at 500 to 2500 mg/l controlled stem stretch during postharvest evaluation in *Narcissus pseudonarcissus* resulting in 19% shorter plants (25.7 cm tall) than control. Plant height of 'Tete a Tete' narcissus during greenhouse forcing was not controlled at any concentrations used. Foliar sprays of 1000 to 2000 mg/l recommended to maintain a marketable plant height.

Helenet *et al.* (2007) reported that application of ethephon spray at 500 and 1000 mg/l twice (applied 1 week after the initial treatment) resulted in 15-25% more compact plants than untreated controls of blanket flower "Torch Flame" (*Gailardia pulchella*). Dry weight of plants (34%), growth indices was significantly lowered. Increasing the rate of application increased the visual compactness.

William *et al.* (2010) reported that substrate drench of ethephon 250mg/l applied in *Narcissus* cultivars resulted 20% to 40% shorter plants than control by inhibiting stem elongation and the effect increased with increased concentrations (250 and 500 mg/l). Among Bedding plants (*Catharanthus*) ethephon drench suppressed plant height by 30% but only 10% to 15% in *Lobelia lycopersicon*, *Celosia*, and *Tagetes*. Dry mass accumulation is decreased in all crops.

Curry and Erwin (2012) reported that spray application of ethephon (250-1000ppm) on 11 *Kalanchoe* species (applied 2 weeks after pinching) inhibited stem elongation by 2.9 cm (37% less) in all species compared with untreated plants. Ethephon increased the number of branches for, *Kalanchoe rosei* and *Kalanchoe glaucescens* species by 1.6 and 3.6 branches. Phyto toxicity was observed in *Kalanchoe manginii* at 1000 ppm, the apical meristem was distorted, resulting in stunted plants with few unfolded leaves and branches. At 20 ppm, *Kalanchoe rotundifolia* plants were very stunted.

### 2.1.3.2 Effect of Ethephon on flowering

Harry *et al.* (1990) reported that Ethepon 500 ppm spray in Zonal geraniums (*Pelargonium hortorum*) produced more inflorescences than control plants. Flowering delay typically associated with ethephon is not seen in the experiment which appeared to be an anomaly.

Starman and Williams (2000) reported that the spray application of ethephon ((500-1000mg/l) reduced number of flowers and delayed flowering by 8 to 11 days in *Scaevola aemula*. There is no reduction in number of flowers per stem which gave floriferous, compact clusters of appearance of the flowers, spike-like inflorescences at the end of the stem.

Burnett *et al.* (2000) reported application of ethephon 500 and 1000ppm delayed flowering by 11 to 13 days in the first year of experiment in *Achillea* cv. 'Coronation gold' and *Gaura lindheimeri* cv. 'Corrie's gold'. Some treated plants did not reach marketable quality with fewer and smaller flowers. In the second year of experiment flowering delay and decrease in number of flowers were not seen as flower buds were not visible during the treatment.

Banon *et al.* (2003) reported that the application of ethephon 50, 75 and 100 mg/plant (25DAT) in *Reichardia tingitana* delayed the flowering. Number of flowering stems and number of inflorescences per plant were significantly reduced. Flower size, internodal distance and number of flowering buds were substantially reduced.

Haque *et al.* (2007) reported that ethereal applied at 50, 100, 250 and 500 mg/l in *Chrysanthemum cinerariifolium* produced positive effect on pyrethrins level by 20 and 26% in pyrethrin-1 and by 31 and 44% in pyrethrin-2 and significantly increased fresh and dry flower yield (38 to 42%) as compared to untreated plants. Flower yield decreased by higher doses of etherel (250 to 500 mg/l) but single flower weight was not affected significantly.

Helen *et al.* (2007) reported that application of ethephon spray at 500 and 1000 mg/l resulted in delay of flowering in blanket flower "Torch Flame" (*Gailardia pulchella*) regardless of application rate or number. Pedicel

elongation was reduced in treated plants compared to control. Number of flowers was not affected by a second spray (at 3 weeks) of application.

### **2.1.3.3 Effect of Ethephon on vase life**

Finger and Campanha (1999) reported that the application of ethephon at 10 and 100, 1000 mg/l in Bird of paradise (*Strelitzia reginae*) had little influence on flower longevity (vase life) which is attributed to the apparent lack of sensitivity to ethylene of this flower, even though it is known that ethylene causes senescence and wilting of petals and tepals in many flower species.

Van Droon *et al.* (2011) reported that the application of ethephon limited the vase life of Cut Tulips (*Tulipa* spp.) by a combination of leaf yellowing, tepal senescence, and tepal abscission. Stem bending which is resulted by high rate of stem elongation could be prevented by treatment with ethylene or ethephon. However, these treatments resulted in poor flower opening. The ethephon treatment also resulted in precocious tepal abscission. The negative effect of ethephon on flower opening was overcome by a treatment with gibberellic acid.

### **2.1.4 Effect of Uniconazole**

Uniconazole is a member of the triazoles, a potent new class of chemical growth regulators which are more effective at lower concentrations than others. It is known by chemical name [(E) – (p-chlorophenyl)-4,4-dimethyl-2-(1,2,4-triazol-1-yl)-1-penten-3-ol] and trade name as Sumagic.

The most effective plant growth response is height control on a wide range of plant material, including woody ornamentals, turf grass, fruit crops, bedding plants and potted floricultural crops (Davis *et al.* 1988) Specifically, effective height control with uniconazole has been demonstrated in chrysanthemums by Starman *et al.* (1990). Uniconazole retard stem elongation of many plant species and in most cases, thick dark green appearance of leaves has been correlated with increased chlorophyll content. It is also a promising tool to increase productivity, yield in ornamental crops.

#### 2.1.4.1 Effect of Uniconazole on growth parameters

Starman (1990) reported that multiple sprays of uniconazole at 5, 10 and 20 mg/l were effective in reducing the height of chrysanthemum (*Dendranthema grandiflorum*) applied 2 weeks after pinching. Plant height and time to marketability were decreased linearly with increasing concentrations of uniconazole.

Anderson and Hartley (1990) reported that 2 soil applications of uniconazole reduced plant height to a 30 cm in Satin flower (*Clarkia amoena*). One or two soil applications of uniconazole 16.5 ppm gave the most acceptable height control of 'Grace Rose Pink' while 'Grace Shell Pink' required three or four applications for equal height. Under 24 hr supplemental lighting, two soil applications at 15 ppm significantly reduced the plant height five weeks after transplanting.

Hicklenton *et al.* (1990) reported that application of uniconazole as soil drench (0.02 mg a.i./pot) or foliar spray (0.028 or 0.056 mg a.i. /pot) 10 days after removal of shoot tip in three cultivars of Chrysanthemum (*Dendranthema grandiflora* Tzvelev.) reduced plant height and shoot dry weight. Higher doses resulted in further reduction in plant height.

Harry *et al.* (1990) reported that the application of uniconazole at 10 ppm spray and drench reduced stem elongation in Zonal geraniums (*Pelargonium hortorum*) resulting in lower plant height and increased branching. Drench application severely restricted the growth and excessive dwarfing of leaves, petioles. No phytotoxicity was observed.

Wilfert (1990) reported that single uniconazole spray at 20 ppm was effective than two sprays at 10 ppm (applied 2 weeks after pinching) in controlling the plant height (<13.5in) of Chrysanthemum (*Dendranthema grandiflora*). In cultivar 'Brightlight', shortest treated plants are two foliar sprays at 10 ppm and in 'karma' one spray (10 ppm) produced well-proportioned plants.

Starman (1991) reported that Uniconazole single spray application (2weeks after pinching) at 10mg/l and two applications at 5mg/l (2 and 3 weeks

after pinching) or a drench at 1.6 mg a. i /pot (2weeks after pinching) in *Eustoma grandiflorum* gave equally good height control.

Harry and Stephen (1992) reported that single uniconazole spray (15 mg a.i/ l) and drench (600µg/pot) application reduced stem elongation strongly causing growth retardation of 12 to 22% in pot Chrysanthemum (*Dendranthema grandiflorum*). The PGR applications reduced the number of internodes and internodal length of the plants compared to control.

Gilbertz (1992) reported that spray applications of 15 or 30 mg/l uniconazole in *Dendranthema grandiflora* 'Bright Golden Anne' (4 weeks after pinching) significantly reduced the plant height (27 to 43%) and shoot dry weight. Excessive height reduction (53%) was occurred when applied at 0 or 2 weeks after pinching.

Schuch (1994) reported that foliar spray of uniconazole at 10 mg/l resulted in plants 33% shorter than control in *Dendranthema grandiflora*. Uniconazole reduced internodal lengths and stem, root and total plant dry weight (48%), canopy width (25%) and increased chlorophyll content of leaves and leaf area compared to untreated plants. Higher concentrations (two 10 mg/l sprays) increased leaf thickness and reduced transpiration up to 47% per leaf area.

Gent (1997) reported that application of uniconazole applied 1 to 10 mg per plant reduced the growth and dry weight in four cultivars of *Rhododendron catawbiense* and *Kalmia latifolia* and reduced stem elongation (50%) equally in the year of application. In second year stem elongation was inhibited (12%) by higher dose (20 mg /plant). Leaves were smaller in size compared to control in *Kalmia* and stem diameter was similar to control in treated plants.

Kim *et al.* (1998) reported that uniconazole spray applications at 1 and 2 mg/l and drenches at 0.1 and 0.2 mg a.i., significantly reduced total plant height effectively up to 58% in Dutch grown Bleeding Heart (*Dicentra spectabilis*) Chlorophyll content was increased producing deep green leaf colour. Total number of shoots per tuberous roots and stem strength were not affected.

Starman and Williams (2000) reported that the uniconazole drench 1 – 2 mg/ l in *Scaevola aemula* reduced plant width significantly in cv. 'New Wonder' and 'Purple Fan' resulting in growth reduction. The 2.5 and 5 mg/l rates resulted in excessive growth reduction coupled with leaf curling and cupping. Foliar spray at 20 mg/l decreased plant width in all cultivars.

Arnold and McDonald (2001) reported that uniconazole sprays of 60 and 120mg/l reduced the internode extension and plant indices in Blue Plumbago producing a more compact canopy. Uniconazole drenches (6 mg/l) elicited minimal reductions in growth. No residual effect was found with the treatments.

Warner and Erwin (2003) reported that one-time spray application of uniconazole (5 and 10mg/l) reduced stem elongation of *Hibiscus radiatus* by 19 % ( 28 days after application) but did not impact stem elongation in *Hibiscus trionum* compared to untreated plants. Therefore, multiple applications or higher doses may be necessary for adequate control. Application in *Hibiscus rosa-sinensis* resulted in reduced plant height by 75% and darker green colour in leaves.

Helen et al. (2007) reported that drench application of Uniconazole at 6 and 12 mg/l and spray application at 60 and 120 mg/l resulted in reduced growth indices (12% to 30%) and dry weights (16 to 31%) in blanket flower (*Gailardia pulchella*), with greater compactness than control plants. Increasing the rate of application linearly decreased the parameters. Drench application was more effective compared to spray application of uniconazole which is attributed to the greater chemical uptake by roots and transportation through xylem.

Gaber (2009) reported that application of uniconazole drench or spray in six concentrations (0.20,30,40,50 and 60 ppm) reduced the plant height in *Mirabilis jalapa* compared to control and significantly retarded the internodal length. Leaf area was less with 50 and 60 ppm. Shoot dry weight was decreased with 20 to 60 ppm foliar spray. Number of internodes and leaf carotenoids and chlorophyll content were increased. There was reduction in sugar content during both seasons of the experiment.

Currey (2010) reported that application of uniconazole at 1.0 to 2.0 ppm suppressed final stem length (3.7 to 5.2 cm. shorter) of *Calibrachoa* (*Calibrachoa\*hybrid*) and plant height (10.0 to 11.3 cm. shorter) of Pansy (*Viola wittrockiana*) after planting in containers filled with substrate containing 80% peat and 20% parboiled Rice Hulls. Based on these results it is concluded that Rice Hulls did not reduce PGR drench efficacy on plants.

Nazarudin (2012) reported that uniconazole spray applications at 2 mg/l significantly reduced the plant height (15.6%) and leaf area (59.6%) in *Hibiscus rosa-sinensis*. Chlorophyll content was significantly higher in treated plants (30.6%) made the leaves appear greener. Increased root length (38.1%) was found in treated plants than control.

Currey and Erwin (2012) reported that foliar spray of uniconazole ( 5 – 20 ppm ) on 11 *Kalanchoe* species ( applied 2 weeks after pinching ) inhibited stem elongation by 4.9 cm ( 63% less ) in all species compared with untreated plants. Stem elongation inhibited by 4.2 cm (44%) in *kalanchoe fedtschenkoi* and *inkalancoe pumila* by 3.0 cm (47%). The highest suppression was 7.2 cm (85% less) in *Kalanchoe spectrantha* and severe stunting was observed with 20 ppm application in *kalanchoe glaucescens*.

#### **2.1.4.2 Effect of Uniconazole on flowering**

Harry *et al.* (1990) reported that the application of uniconazole at 10 ppm spray and drench reduced the numbers and size of inflorescences, peduncle length in Zonal geraniums (*Pelargonium hortorum*). Time to flowering was not delayed and days to anthesis were unaffected in treated plants

Hicklenton *et al.* (1990) reported that uniconazole sprayed at 0.028mg a.i / pot and drench at 0.02 mg a.i./pot reduced flower area, flower dry weight in three cultivars of chrysanthemum (*Dendranthema grandiflora* Tzvelev.). Flowering was delayed by 2-4 days in each cultivar by post-plant treatment of uniconazole.

Starman (1991) reported that uniconazole drench application at 1.6 mg a.i / pot increased number of flowers in *Eustoma grandiflorum* and did not reduce the flower size. Number of days to flower increased with increased spray (10 mg / l) concentrations but decreased with drench concentrations. Flower fresh and dry weights and peduncle length were decreased with increased single drench and foliar spray concentrations. Petal length reduced linearly with increase in doses.

Gilbertz (1992) reported that spray applications of 15 or 30 mg/l uniconazole in *Dendranthema grandiflora* 'Bright Golden Anne' (4 weeks after pinching) lengthened the time to flowering by 3 days than control. Flower diameter was reduced up to 9% by the treatment.

Wang and Hsu (1994) reported that application of uniconazole (100 to 200 mg/l) as seedling dips did not affect the blooming date but effectively reduced the inflorescence length and stalk elongation (45% less) in *phalaenopsis* Orchids. Increasing concentrations produced progressively less growth of inflorescence. Foliar treatments were less effective than dipping. Flower size, count and thickness were unaffected.

Schuch (1994) reported that foliar spray of Uniconazole at 10 mg/l and 1.25 mg/l cuttings dip treatment on *Chrysanthemum (Dendranthema grandiflora)* at 5 weeks after pinching reduced the number of inflorescences per plant (18%). Inflorescence dry weight was reduced up to 44% compared to the control and time to anthesis was unaffected.

Listyani *et al.* (1996) reported that application of 1 ppm of uniconazole to 7- day-old seedlings subjected to a 15 hr dark treatment inhibited the flowering of *Pharbitis nil*. The inhibition by uniconazole was overcome by application of GA to the plumules and was found that endogenous GA's were required for the flowering during or just after the dark period. The GA levels in treated shoots remained low, indicating that GA bio synthesis in the whole seedling was almost suppressed by uniconazole.

Kim *et al.* (1998) uniconazole spray applications at 1 and 2 mg/l and drenches at 0.1 and 0.2 mg a.i., significantly delayed flowering by 3 to 6 days in Dutch grown Bleeding Heart (*Dicentra spectabilis*) and number of flowering shoots was not affected. Total number of inflorescences was significantly increased by 0.2 mg a.i per pot media drench. Height of inflorescences was decreased.

Starman and Williams (2000) reported that the uniconazole drench 1–2 mg/l, in *Scaevola aemula* decreased flower stem number and length significantly. Flower stem number per cm is increased in all cultivars resulting in floriferous appearance. There was no delay in flowering of treated plants. Spray application did not affect most of the flowering variables.

Gaber (2009) reported that application of uniconazole drench or spray in six concentrations (0.20, 30, 40, 50 and 60 ppm) significantly decreased the number of flowers per plant at 30 and 40 ppm sprays in first year and at 20 and 60 ppm sprays in second year. Flowering was delayed significantly in both seasons.

Nazarudin (2012) reported that uniconazole spray applications at 2 mg/l significantly increased number of flower buds at 10 weeks after treatment but delayed blooming in *Hibiscus rosa-sinensis*. Uniconazole was found to be more effective in promoting flowers compared to control and therefore recommended for flower induction at 2 mg/l in potted *Hibiscus*. A significant positive relation was found between number of blooms and total root length.

#### **2.1.4.3 Effect of Uniconazole on vase life**

Hamada *et al.* (1989) reported that the application of 20 mg/l uniconazole treatment was extended vase life of cut flowers in Tree peony but in herbaceous peony, treatment did not extend vase life of cut flowers. The application delayed opening of petals in cultivar ‘Taiyoh’

Stamps (1990) reported that the foliar spray application of uniconazole at 25 and 100 ppm in Vibranum Stems (*Viburnum odoratissimum*) and Variegated Chinese privet (*Ligustrum indica*) reduced the vase life by 7.7 and 7.2 days respectively when compared to control plants.



## **CHAPTER- III**

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### **MATERIAL & METHODS**

## **CHAPTER III**

# **MATERIAL AND METHODS**

The materials used and the methods followed during the course of present investigation are briefly described here under.

### **3.1 LOCATION OF THE EXPERIMENT**

The field experiment was conducted at Floriculture Research Station, Rajendranagar, Hyderabad during Rabi 2015-2016. The experimental field is situated at an altitude of 542.3 m above sea level on 17<sup>o</sup> 19' North latitude, 79<sup>o</sup> 23' East longitudes.

### **3.2 WEATHER CONDITIONS DURING THE CROPPING PERIOD**

The meteorological data pertaining to mean minimum and maximum temperatures, relative humidity and rainfall in weekly averages during the period of investigation *i.e.* Rabi 2015-16 season recorded at Floriculture Research Station Rajendranagar, Hyderabad are presented in Appendix 1.

### **3.3 EXPERIMENTAL DETAILS**

The experiment on “Impact of growth retardants on growth and floral characters of chrysanthemum potmums (*Dendranthema grandiflora*)” was conducted during Rabi season 2015-16. The recommended package of practices was followed. Necessary plant protection measures were carried out uniformly to safe guard the plants.

#### **3.3.1 Planting material**

The experiments were carried out with the chrysanthemum variety “HYDC – 9”. Thirty days old plants were obtained from the nursery grown in floriculture research station, Rajendranagar, Hyderabad.

### 3.3.2 Characteristics of cultivar

HYDC – 9 is a semi hardy plant with semi upright growth habit having serrated leaf margins and rounded shape of the leaf base. Size of the stipule is small. Inflorescence is corymbiform and flower head is pompon. Flowers are small, pink in colour and had ligulate type of ray florets. It is economically used as a potmum.

### 3.3.3 Design and layout

The experiment was laid out in completely randomized block design with 14 treatments and 3 replications with four pots per replication.

The layout plan of the experiment is illustrated in Fig. 3. 1.

Name of the crop	: Chrysanthemum
Variety	: HYDC-9
Design	: Completely Randomized Design
Number of treatments	: 14
Replications	: 3
Number of pots per replication	: 4
Pot size	: 20 cm diameter
Location of work	: Floriculture research station Rajendra Nagar, Hyderabad

### 3.3.4 Treatment details

The experiment on “Impact of growth retardants on growth & floral characters of chrysanthemum potmums (*Dendranthema grandiflora*)” was conducted at floriculture research station, Rajendranagar, Hyderabad during 2015-16. The treatmental details of the experiment are presented below.

1. T<sub>1</sub> : Paclobutrazol @ 30ppm
2. T<sub>2</sub> : Paclobutrazol @ 60ppm

3. T<sub>3</sub> : Paclobutrazol @ 90ppm
4. T<sub>4</sub> : Daminozide @ 500ppm
5. T<sub>5</sub> : Daminozide @ 750ppm
6. T<sub>6</sub> : Daminozide @ 1000ppm
7. T<sub>7</sub> : Ethephon @ 250ppm
8. T<sub>8</sub> : Ethephon @ 500ppm
9. T<sub>9</sub> : Ethephon @ 750ppm
10. T<sub>10</sub> : Ethephon @ 1000ppm
11. T<sub>11</sub> : Uniconazole @ 4ppm
12. T<sub>12</sub> : Uniconazole @ 8ppm
13. T<sub>13</sub> : Uniconazole @ 16ppm
14. T<sub>14</sub> : Control

### **3.4. CULTIVATION DETAILS**

The following operations were carried out for the cultivation of crop during the course of investigation.

#### **3.4.1. Nursery**

A raised nursery bed of 1m width and 10 m length was prepared at a well-drained location of the floriculture unit. All stones and stubbles were thoroughly removed and the bed surface was finely leveled. Healthy terminal cuttings were collected and planted in the nursery bed. Water was applied as a fine shower with a rose can. Weeds were removed as and when they appeared.

#### **3.4.2. Preparation of the experimental site**

The experimental site was cleaned and made free of weeds, grasses and stones. The site was leveled with spade so that the pots rest evenly on the surface. A gap of 20 cm was left in between the pots. Each treatment was done in three

replications and each replication consisted of four pots and each pot contained a chrysanthemum rooted cutting.

#### **3.4.3. Preparation of potting media**

Pots of 20 cm diameter were selected and filled with potting media. Potting media was composed of Red earth, FYM, Sand, Cocopeat in 2:1:1:1/4 ratio. All the stones and stubbles were collected manually and disposed out of the potting media. 5 Kg of potting mixture was filled in each pot.

#### **3.4.4. Transplanting**

Among the rooted cuttings, strong and uniform cuttings were selected and one rooted cutting was transplanted in each pot. The rooted cuttings were transplanted on 30th day from the day they were planted in nursery bed.

#### **3.4.5. Gap filling**

Certain gaps were observed one week after transplanting due to mortality of saplings. Such gaps were filled by transplanting the rooted cuttings.

#### **3.4.6. Pinching**

Pinching is done to control apical dominance at the height of 10 cm, 20 days after planting in pots

#### **3.4.7. Preparation of growth retardant solution**

Growth retardant solutions were prepared by dissolving the required quantities of chemical in distilled water and volume was made up to one litre.

##### **3.4.7.1. Preparation of Paclobutrazol solution**

Treatment wise paclobutrazol solutions of 30 ppm, 60 ppm, 90 ppm were prepared by dissolving calculated quantity of chemical (30 mg, 60 mg, 90 mg) in distilled water and volume was made up to one litre. Paclobutrazol was applied @ 6.25 mg, 12.5 mg, and 18.75 mg per pot respectively.

#### **3.4.7.2. Preparation of Daminozide solution**

Treatment wise daminozide solutions of 500 ppm, 750 ppm, 1000 ppm were prepared by dissolving the required quantities of chemical (500 mg, 750 mg and 1000 mg) in small quantity of methyl alcohol and volume was made up to one litre with distilled water. Daminozide was applied @ 100 mg, 150 mg, 200 mg per plant respectively.

#### **3.4.7.3. Preparation of Ethephon solution**

Treatment wise ethephon solutions of 250 ppm, 500 ppm, 750 ppm, 1000 ppm were prepared by dissolving the required quantities of chemical (0.25 ml, 0.50 ml, 0.75 ml, 1.00 ml) in distilled water and volume was made up to one litre. Ethephon was applied @ 0.057ml, 0.114 ml, 0.171 ml, 0.228 ml per plant respectively.

#### **3.4.7.4. Preparation of Uniconazole solution**

Treatment wise uniconazole solution of 4 ppm, 8 ppm, 16 ppm were prepared by dissolving the required quantities of chemical (4 mg, 8 mg, 16 mg) in small quantity of methyl alcohol and made to volume of one litre with distilled water. Uniconazole was applied @ 0.72 mg, 1.44 mg, 2.88 mg per pot respectively.

#### **3.4.8. Imposition of treatments**

The treatments were imposed 1 month after transplanting in order to allow proper growth and initial establishment of plants. The pots were watered well before the day of treatment. Paclobutrazol, uniconazole were applied as drench (direct application to the growing medium) whereas daminozide, ethephon were applied as foliar spray with hand sprayer.

#### **3.4.9. Fertilization**

19:19:19 fertilizer was applied at 5g / pot at monthly intervals. 20mg / pot of Neem cake was applied twice during the crop period.

#### **3.4.10. Interculture**

Weeding was done with the help of hand hoes at 20 to 25 days after planting and repeated every month. There were few problems of pests and diseases. Two sprays with an insecticide, Rogor @ 2 ml / l of water for Aphid control and a fungicide Dithane M-45 2.0 mg / l of water for Septoria leaf spot control were taken up. Diluted neem oil of 10 ml / l of water also sprayed for Thrips control, twice during the crop period.

#### **3.4.11. Irrigation**

Plants were irrigated manually at every alternate day.

### **3.5. OBSERVATIONS RECORDED**

Four plants were selected randomly from each replication of treatment and tagged for the purpose of recording the data on following observations.

#### **3.5.1. Vegetative Parameters:**

##### **3.5.1.1. Plant height (cm):**

The height of the plant was measured with meter scale from the base of the plant to the top of the plant canopy at the time of first flower bud appearance.

##### **3.5.1.2. Number of primary branches per plant:**

The total number of primary branches of tagged plants was recorded at 90 DAT and the averages were computed.

##### **3.5.1.3. Plant spread (cm):**

The maximum horizontal spread of the tagged plants in each plot were measured in East-West and North-South direction at the time of first flower bud appearance and expressed in centimeters.

#### **3.5.1.4. Leaf width (cm):**

Leaf width was recorded at the widest point of the leaf and average of 4 fully developed leaves of tagged plants was computed at 50 DAT.

#### **3.5.1.5. Leaf length (cm):**

Leaf length was considered from leaf petiole base to leaf lamina tip and average of 4 fully developed leaves from tagged plants was computed at 50 DAT.

#### **3.1.5.6. Spad Chlorophyll Meter Reading (SCMR Value)**

SCMR value from tagged plants is measured at 65 DAT by SPAD-502 meter.

#### **3.5.1.7. Internodal length (cm):**

The length between the two nodes from the middle portion of plants was recorded at 70 DAT from tagged plants and averages were computed.

#### **3.5.1.8. Diameter of the main stem (mm):**

Diameter of the main stem just above the soil surface was recorded at flowering stage, with digital Vernier calipers.

### **3.5.2. Floral parameters:**

#### **3.5.2.1. Days to first flower bud initiation**

Number of days taken from transplanting to first flower bud appearance was recorded in tagged plants.

#### **3.5.2.2. Number of flower stems per plant**

Total number of flowering stems per plant was counted in tagged plants and averages were computed.

#### **3.5.2.3. Number of flowers per stem**

Total number of flowers per stem was counted in tagged plants and averages were computed

#### **3.5.2.4. Number of flowers per plant**

Total number of flowers from each tagged plant was counted and average number of flowers produced per plant was worked out.

#### **3.5.2.5. Peduncle length (cm)**

Length of the peduncle was measured with scale and expressed in centimeters.

#### **3.5.2.6. Flower diameter (cm)**

The diameter of the flower was measured at full flower opening stage at maximum breadth of the flower using scale from four selected flowers from each tagged plant and average flower diameter was computed.

#### **3.5.2.7. Weight of the flower (g):**

Weight of the flower was measured from four selected flowers of tagged plants and average weight was computed and expressed in grams.

#### **3.5.2.8. Days to 50% flowering**

The data on number of days taken for 50% flowering was recorded by counting the number of days taken from transplanting to till 50% of plants showed first flowering.

#### **3.5.2.9. Duration of flowering (days)**

Total number of days taken for completion of flowering of an individual plant was recorded.

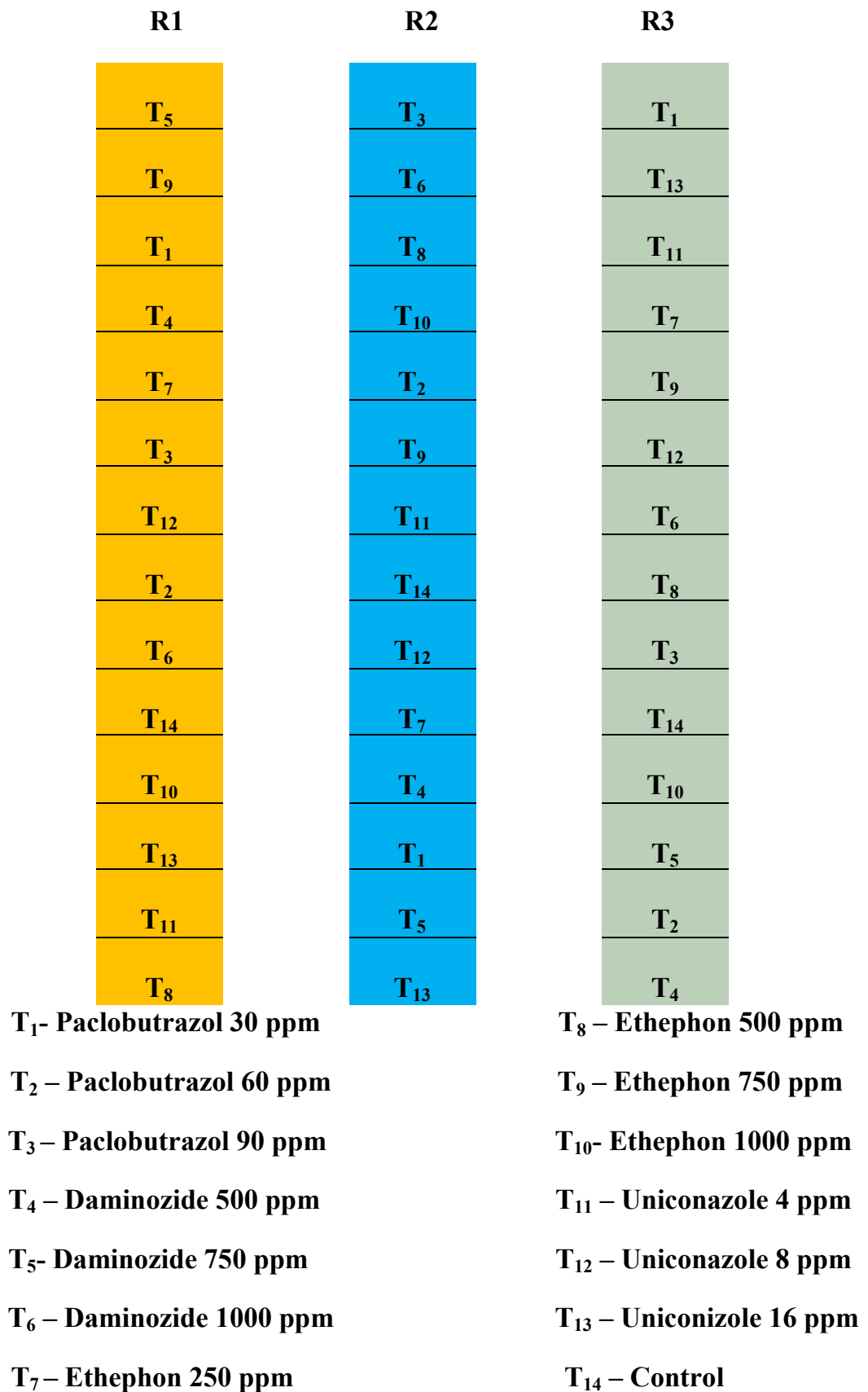
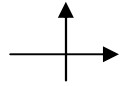
#### **3.5.2.10. Vase life (days)**

Fresh flowers with stalks were kept in distilled water at room temperature and vase life was evaluated by counting the number of days taken for withering and senescence of outer whorl of petals recorded at two days interval.

### **3.6. STATISTICAL ANALYSIS**

The data collected on various observations during the course of investigation were statistically analyzed by adopting the standard procedure of Panse and Sukhatme (1985) and means were taken for the comparison and interpretation of results. The data from study was subjected to analysis in Completely Randomized Design. Significance was tested by the “F” value at 5 percent level of probability. Critical difference and standard error of means were calculated for the effects and incorporated in tables to facilitate treatment comparison.

**Fig. 3.1: Lay out plan of the experimental site**



## **CHAPTER -IV**

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# **RESULTS AND DISCUSSION**

## CHAPTER IV

# RESULTS AND DISCUSSION

The investigations were conducted on the “Impact of growth retardants on growth and floral characters of chrysanthemum potmums (*Dendranthema grandiflora*)”. The data was statistically analysed and the results obtained from the experiment are tabulated and discussed in the light of available literature and presented in this chapter.

### **4.1 Vegetative characters**

#### **4.1.1 Plant height (cm) at first flower bud appearance**

The data regarding plant height at first flower bud appearance under the influence of different treatments with plant growth retardants are presented in Table 4.1.1 and Figure 4.1.1.

Significant differences were recorded with respect to plant height among different treatments. Maximum reduction in plant height (16.92 cm) was recorded with application of paclobutrazol at 90 ppm compared to control and was on par with paclobutrazol 60 ppm (17.42 cm), paclobutrazol 30 ppm (18.58 cm) and uniconazole 16 ppm (18.33 cm). Maximum plant height was recorded in control (47.06 cm) whereas minimum reduction in plant height was recorded with application of ethephon 250 ppm (36.75 cm). Moderate reduction in plant height was recorded with daminozide 1000 ppm (24.25 cm) followed by daminozide 500 ppm (24.92 cm).

From the above results it is evident that there was no difference in plant height initially but after application of growth retardants plant height was decreased in comparison to control plants. Among all growth retardants paclobutrazol treatments were found more effective in retarding plant height but caused undesirable and excessive reduction in height of chrysanthemum pot mums. Paclobutrazol treatments at 60 ppm and 90 ppm produced 63 to 64 % shorter plants

compared to control. Application of daminozide at 1000 ppm caused moderate reduction (48.50%) of plant height resulting in uniform growth of the chrysanthemum pot mums and produced higher quality of potted plants.

In the present experiment paclobutrazol resulted in shorter plants by retarding stem elongation and had a great significance in shortening stem internodes and reducing plant height. These reports are in confirmation with the findings of Latimer (1991) in *Zinnia elegans* and *Tagetes erecta*, Nazaruddin (2012) in *Hibiscus rosa-sinensis*, Gilbertz (1992) in *Dendranthema grandiflora*, Barrett and Nel (1986) in *Chrysanthemum morifolium*, Laurence (2002) in ornamental Sun flower.

Plant growth retardants acts in a variety of ways in natural growth mechanism of plant, they either signal down cell division or inhibit cell elongation and reduce plant height by acting in sub epical stem, and consequently the plant become dwarf in height as internodes fail to elongate (Krishnamurthy, 1981). The physiological effects of paclobutrazol involves inhibitory effect on gibberellin biosynthesis, which block cytochrome P-450 dependent monooxygenases there by inhibiting oxidation of ent - kaurene in to ent –kaurenoic acid in GA synthesis (Rademacher, 1991).

However application of daminozide was found to retard the plant height moderately and found to be ideal for chrysanthemum pot mum variety. These results are in conformity with the findings of Cramer and Bridgen (1998) in *Mussaenda* ‘Queen Sirkit’, Kim *et al.* (1998) in *Dicentra spectabilis*, Zidovic *et al.* (2000) in *Lavandula vera*. Growth retardants like Daminozide commercially known as Alar or B-Nine is successfully applied to control lodging of plants, height, branching and obtain higher yields in chrysanthemum (Karlovic *et al.* 2004). Daminozide as a structural mimic of 2-oxoglutaric acid, inhibit the soluble oxygenases, enzymes which are responsible for the conversion of gibberellin A<sub>12</sub> (GA<sub>12</sub>) – aldehyde to GAs with intrinsic biological activity such as GA<sub>4</sub> and GA<sub>1</sub> by competing for the co-factor binding site (Rademacher, 2000).

#### 4.1.2 Number of primary branches per plant (at 90 DAT)

The data pertaining number of branches per plant in chrysanthemum potmums treated with different growth retardants is presented in Table 4.1.2. The number of primary branches per plant was significantly influenced by various growth retardant treatments.

Maximum number of primary branches being recorded in treatment of paclobutrazol 30 ppm (7.83) which was on par with ethephon 750 ppm (7.75), uniconazole 8 ppm (7.16) whereas minimum number of primary branches was observed with daminozide 500 ppm (6.08) which was on par with control (6.33).

The increase in production of number of primary branches per plant by the application of paclobutrazol was also observed by Vaghshia and Polara (2015) in *Chrysanthemum*, Banon (2001) in *Nerium olender*, Dorajee rao (2012) in *Chrysanthemum coronarium*. Increased branching by the application of uniconazole was also found by Harry *et al.* (1990) in *pelargonium hortorum*. The physiology behind the increase in number of primary branches per plant with triazoles application was that the growth retardants can suppress the apical dominance which could be due to lower levels of endogenous production of gibberellins and, release axillary buds thereby enhancing branching (Cathey, 1964).

Similar effect of increased branching by the application of ethephon was also found by Currey and Erwin (2012) *Kalancho erosei* and by Banon *et al.* (2003) in *Reichardia tingitana*. Exogenous application of an ethylene generators can suppress apical dominance and release axillary buds by lowering ratio of auxin to cytokinin or ethylene there by enhance branching (Sim *et al.* 1997).

In the present experiment there was slight decrease in number of branches with application of daminozide 500 ppm. Similar reduction in number of laterals with application of daminozide was also found by Ahmad Bhat *et al.* (2011) in

*Erysimum marshalii*, Zidovic *et al.* (2000) in *Lavandula vera*, Zakrzwski (2011) in *Chrysanthemum grandiflorum*.

#### **4.1.3 Internodal length (cm)**

The data recorded on internodal length among different treatments of growth retardants was presented in Table 4.1.3 and Figure 4.1.3. Significant difference was found between the treatments with respect to internodal length.

Maximum reduction in internodal length was recorded with paclobutrazol 60 ppm (0.50 cm) which was on par with uniconazole 16 ppm (0.50 cm), paclobutrazol 90 ppm (0.53 cm), paclobutrazol 30 ppm (0.54 cm) compared to control (2.55 cm). Minimum reduction in internodal length was recorded with ethephon 500 ppm (1.37 cm) which was on par with ethephon 1000 ppm (1.33 cm) whereas moderate reduction of internodal length was recorded with daminozide 1000 ppm (0.86 cm) which was on par with daminozide 500 pm (0.87 cm).

With the above results it was evident that, among all growth retardants paclobutrazol treatments were found more effective in reducing internodal length of the treated plants when compared to control plants. This reduction of internodal length by paclobutrazol application was also reported by Banon *et al.* (2001) in *Nerium oleander* Barrett and Nell (1983) in *Ficus benjamina*. Davis *et al.* (1989) stated that Triazole growth retardants, with drench application move directly into the xylem to the vascular system behind the apex, the xylem is thought to act as a reservoir, maintaining a sufficiently high concentration of growth inhibitor to reduce internodal elongation.

In the present study highest reduction in internodal length was also reported by the application of uniconazole 16 ppm. These findings are in line with the earlier reports of Arnold (2001) in Blue Plumbago, Harry and Stephen (1992) in *Dendranthema grandiflora*. Adriansen (1997) stated that uniconazole is a Triazole compound having similar chemical structure of paclobutrazol that suppresses stem elongation by inhibition of gibberellic acid biosynthesis.

However, application of daminozide 1000 ppm caused moderate reduction of internodal length of the plants resulting in optimum growth of the plant. Similar reduction of internodal length by the application of daminozide was also reported by Chen (2002) in *Gynura aurantiaca*, Sheibany *et al.* (2007) in *Chrysanthemum morifolium*. Reduction in internodal length may be attributed to the suppression of apical dominance completely by inhibiting cell division and extension in the sub apical meristematic zone of the stem, there by resulting in short internodes (Davis *et al.* 1988).

#### **4.1.4.1 Plant spread E-W (cm)**

The data presented in Table 4.1.4.1 reveal significant variation among the different growth retardant treatments pertaining to plant spread in E-W direction.

Maximum reduction in plant spread was recorded in paclobutrazol 90 ppm (19.42 cm) which was on par with paclobutrazol 30 ppm (20.17 cm), paclobutrazol 60 ppm (22.83 cm), uniconazole 16 ppm (21.00 cm). Minimum reduction of plant spread (E-W) of potmums was recorded in ethephon 750 ppm (48.67 cm) which was on par with ethephon 250 ppm (45.58 cm) compared to control (37.92 cm) whereas moderate reduction in plant spread E-W was recorded with daminozide 1000 ppm (32.75 cm) which was on par with daminozide 500 ppm (30.83 cm).

The observations from table 4.1.4.1 confirm that the application of ethephon increases plant spread E-W. Similar results with application of ethephon were obtained by Helen *et al.* (2007) in *Gailardia pulchella*. Barrett (2001) stated that the ethylene causes cells to limit elongation and increase in canopy width.

Paclobutrazol treatments highly reduced plant spread (E-W) direction. Similar reduction in plant spread with the application of paclobutrazol also reported by Christiana *et.al.* (2005) in *zinnia elegans*. Suppression of growth by paclobutrazol occurs due to the blockage of three steps in terpenoid pathway for the production of gibberellins by binding with compounds and inhibiting the enzymes that catalyze the metabolic reactions (Hedden, 1997).

In the present study moderate reduction in plant spread by the application of daminozide might be due to retarded stem and petiole elongation which was also earlier reported by Warner (2003) in *Hibiscus radiatus* and *Hibiscus trionum*, Zakrzwski and Anita Schroeter (2011) in *Chrysanthemum grandiflorum*.

#### **4.1.4.2 Plant spread N-S (cm)**

The data presented in Table 4.1.4.2 reveal significant variation among the different growth retardant treatments pertaining to plant spread in N-S direction.

Maximum reduction in plant spread was recorded with paclobutrazol 90 ppm (17.75 cm) which was on par with paclobutrazol 60 ppm (19.5 cm) and paclobutrazol 30 ppm (20.08 cm). Minimum reduction in plant spread N-S direction was recorded in ethephon 500 ppm (56.08 cm) which was on par with ethephon 750 ppm (55.42 cm), ethephon 1000 ppm (55.08 cm) followed by control (40.83 cm) whereas moderate reduction in plant spread N-S was recorded with daminozide 1000 ppm (33.50 cm) which was on par with daminozide 500 ppm (33.17 cm) and 750 ppm (33.08 cm).

From the above results it is evident that paclobutrazol highly reduced plant spread in N-S direction. Similar results of reduction in plant spread (N-S) by paclobutrazol treatment was also observed by Banon *et al.* (2003) in *Reichardia tingitana*, Gilbertz (1992) in *Dendranthema grandiflora*. According to Barrett & Bartuska (1994) paclobutrazol applied as drench will be absorbed by roots and translocate and to actively growing tissues through the xylem and inhibit cell division by inhibiting gibberellins synthesis there by suppress plant growth.

Application of ethephon increased the plant spread (N-S). Similar result was also reported by Whipker *et al.* (2006) in *Narscissus pseudonarscissus*. Barrett (2001) stated that the ethylene causes cells to limit elongation and increase in plant spread instead.

Moderate reduction in plant spread by the application of daminozide was also reported by Wilfert and Barrett (1994) in *Rhododendron obtusum*. Plant spread (N-S) of treated plants might be reduced by reduction in stem length (Kazemi, 2014).

#### **4.1.5. Leaf length (cm)**

The data recorded on leaf length in potmums as influenced by various growth retardants was presented in Table 4.1.5. Significant differences were found with respect to leaf length among various treatments of growth retardants.

The maximum leaf length was observed in daminozide 1000 ppm (6.26 cm) which was on par with ethephon 500 ppm (5.98 cm) whereas minimum leaf length was found with paclobutrazol 60 ppm (4.39 cm) which was on par with paclobutrazol 30 ppm (4.60 cm) and ethephon 250 ppm (4.69 cm).

The maximum leaf length recorded by daminozide in the present experiment might be due to the moderate reduction of plant growth and uniform growth of the plant. Similar results were also recorded by Ganesh (2014) in *Chrysanthemum* var. 'Punch'.

Reduction in leaf length might be the reason for reduction in leaf area by the application of paclobutrazol. These results are in proximity with Christiana *et al.* (2005) in *Zinnia elegans*, Chen *et al.* (2002) in *Gynura aurantiaca* and Gent (1997) in *Rhododendron*. Morphological modifications of leaves induced by treatment with paclobutrazol such as smaller stomatal pores, thicker leaves would have resulted in the production of low leaf area (Chaney, 2004).

#### **4.1.6. Leaf width (cm)**

Influence of plant growth retardants on leaf width of potmums was recorded and presented in Table 4.1.6.

Significantly maximum leaf width (4.41 cm) was observed with daminozide 1000 ppm which was on par with control (4.28 cm), uniconazole 8 ppm

(4.19 cm), uniconazole 4 ppm (4.24 cm), daminozide 750 ppm (4.22 cm) whereas minimum leaf width was recorded with ethephon 250 ppm (3.38 cm) which was on par with paclobutrazol 30 ppm (3.62 cm), paclobutrazol 60 ppm (3.81 cm), daminozide 500 ppm (3.60 cm), ethephon 750 ppm (3.69 cm).

In the present study increase in leaf width by the application of daminozide might be attributed moderate reduction in plant growth which was also reported by Schuch (1994) in *Dendranthema grandiflora*.

Reduction in leaf width by the application of ethephon might be attributed to the growth suppression. The similar findings were also reported by Banon *et al.* (2001) in *Nerium oleander*. Rademacher (2000) stated that ethephon is an ethylene releasing compound that has been used to suppress the growth in some species.

Reduction in leaf width by the application of paclobutrazol might be due to the reduction in leaf area (Dorajee rao, 2012). These results are similar with the findings of Dorajee rao (2012) in *Chrysanthemum*, Nazaruddin (2012) in *Hibiscus*. The unique structure of paclobutrazol which is Nitrogen containing heterocyclic, allows it to bind to an iron atom in the enzymes essential for the production of gibberellins there by inhibiting gibberellin bio synthesis (Rademacher, 1987).

#### **4.1.7 SCMR value (Spad chlorophyll meter reading)**

Analysis of SCMR value in the leaves of potmums as affected by various concentrations of growth retardants was shown in the Table 4.1.7 and Figure 4.1.7. significant difference between various concentrations of growth retardants was found.

It was evident from the data, that the SCMR value of the leaves was significantly high in paclobutrazol 90 ppm (74.86) which was on par with paclobutrazol 60 ppm (73.25) followed by paclobutrazol 30 ppm (66.42) and uniconazole 16 ppm (60.23) whereas minimum was observed with ethephon 1000

ppm (38.53) which was on par with ethephon 750 ppm (39.87) followed by control (47.43).

From the above results it was evident that SCMR value was highly increased in treatments of paclobutrazol when compared to control. Similar results were also obtained by Banon *et al.* (2001) in Nerium, Nazaruddin (2012) in Hibiscus. The plants treated with paclobutrazol generally have rich green colour suggesting high SCMR value content (Kim *et al.* 1998).

Increase in SCMR value by the application of uniconazole was also reported by Schuch (1994) in *Dendranthema grandiflora*, Gaber (2009) in *Mirabilis jalapa*, Kim *et al.* (1998) in *Dicentra spectabilis*.

The possible explanation for this response was given by Chaney (2004). One is that the leaves of both treated and untreated plants contain the same number of cells, but because the cells in leaves of Triazoles treated plants are smaller, the SCMR value is more concentrated in the reduced cell volume. In addition, the amount of SCMR value is increased because of an increase in the production of phytyl, an essential part of the SCMR value molecule produced via the same terpenoid pathway as gibberellins. Triazoles treatment, which blocks the production of gibberellins, results in a shunting of the intermediate compounds from gibberellin synthesis to the production of even more phytyl.

In the present study application of ethephon reduced the SCMR value of leaves. The reduction in SCMR value by ethephon application was also reported by Banon *et al.* (2003) in *Reichardia tingitana*. An accelerated degradation of chlorophyll by ETH application has been noted in several species (Centurian *et al.* 1998).

#### 4.1.8 Diameter (mm) of the main stem at flowering

Influence of growth retardants on stem diameter in potmums is presented in Table 4.1.8. The effect of growth retardants significantly differed on stem diameter of the chrysanthemum potmums.

Significantly highest stem diameter was recorded in daminozide 1000 ppm (7.73 mm) followed by daminozide 750 ppm (6.95 mm) and ethephon 1000 ppm (6.85 mm) whereas minimum stem diameter was recorded in control (4.50 mm). Application of uniconazole 4 ppm recorded lowest stem diameter (5.48 mm) among the growth retardant treatments.

From the above results it is evident that stem diameter is highly increased in treated plants with daminozide compared to control. Similar results of increased stem diameter with application of daminozide was also reported by Kazaz *et al.* (2010) in *Chrysanthemum morifolium*, Ecker (1992) in *Matthiola incana*, Arnold (2001) in Blue Plumbago, Ganesh (2014) in Chrysanthemum.

The application of growth retardants results in shorter plants as internodes fail to elongate and reduced stem elongation, this decrease in stem length often accompanied by an increase in its thickness (Kazemi *et al.* 2014). Shafshak *et al.* (1976) stated that vascular cambium continued to divide in retardant-treated stems, and cambial parenchyma accumulated up to twice the width in non treated plants of the same age, while cell differentiation was delayed.

Decrease in stem diameter with application of uniconazole was also earlier reported by Gent (1997) in *Rhododendron catawbiense*. Barrett (2001) suggested that uniconazole drenches may reduce cell division, cell elongation during plant growth.

## **4.2 Floral characters**

### **4.2.1 Days taken to 1<sup>st</sup> flower bud appearance**

The data pertaining to first flower bud appearance as influenced by various growth retardants was illustrated in Table 4.2.1 and Figure 4.2.1. There was significant difference observed among the various growth retardant treatments with regards to days taken to first flower bud appearance.

The days taken to first flower bud appearance was maximum in ethephon 1000 ppm (89.00 days) which was on par with ethephon 500ppm (88.67 days), ethephon 250 ppm (88.42 days) followed by ethephon 750 ppm (86.50 days) and control (84.54 days) whereas minimum number of days taken for first flower bud appearance was observed in daminozide 1000 ppm (75.17 days) which was followed by paclobutrazol 90 ppm (76.42 days).

From the above results it was evident that the number of days taken to first flower bud appearance were advanced in daminozide and highly delayed in ethephon treatments when compared to other growth retardant treatments and control.

These results of earlier flowering by the daminozide application were in line with the earlier reports of Krause (2003) in *Tagetes patula* and *Petunia hybrida*. Larson (1985) stated that growth retardants indirectly influence flowering by retarding vegetative growth of floriculture crops. This was in proximity with results found by Ganesh (2014) in *Chrysanthemum*. Daminozide is successfully used to control height, branching and flowering of many plants among others also *Chrysanthemum* (Hayashi *et al.* 2001).

The delayed flowering in ethephon treated plants was also reported by Burnett *et al.* (2000) in *Achillea*, Helen *et al.* (2007) in *Gailardia pulchella*, Banon

(2003) in *Reichardia tingitana*. Ethephon mode of action is delayed flowering by its application to some of the plants (Barrett, 2001).

#### **4.2.2 Days taken to 50% flowering**

The days taken to 50% flowering differed significantly due to different levels of growth retardants (Table 10).

The data on different growth retardant treatments showed that the maximum number of days taken for 50% flowering were observed in ethephon 250 ppm (127.30 days) which was on par with ethephon 500 ppm (126.70 days) which is followed by ethephon 750 ppm (125.00 days) and ethephon 1000 ppm (124.00 days) and control (121.30 days) whereas minimum number of days taken in daminozide 1000 ppm (100.00 days) and was on par with daminozide 750 ppm (100.00 days).

From the above results it is evident that daminozide treatment advanced 50% flowering in treated plants by 21.3 days compared to control plants. The early flowering by the application of daminozide was also reported by Kazemi (2014) in *Calendula officinalis*. Larson (1985) stated that growth retardants promote flower bud initiation in some crops and flower bud development in others.

In this study ethephon treatments highly delayed 50% flowering. Similar results of delayed flowering by the application of ethephon were also reported by Starman and Williams (2000) in *Scaevola aemula*. Ethephon is an ethylene releasing compound which when absorbed by the plant interferes plant growth and flowering (Rademacher, 1991).

#### **4.2.3 Number of flower stems per plant**

The data regarding number of flower stems per plant as significantly influenced by different growth retardants was illustrated in Table 4.2.3.

Perusal of data pertaining to number of flower stems per plant, it was observed that the maximum number of sprays per plant was observed with uniconazole 8ppm (6.83) which was on par with uniconazole 4ppm (6.33),

uniconazole 16 ppm (6.25) which was followed by daminozide 500 ppm (6.16) compared to control (5.66) whereas minimum (5.33) number of sprays per plant was observed with ethephon 1000 ppm which was on par with ethephon 500 ppm (5.41), ethephon 250 ppm (5.41).

From the above results it is evident that the number of sprays per plant was high in uniconazole treated plants when compared to control. These results are in line with the earlier findings of Seung Hyun Kim *et al.* (1998) in *Dicentra spectabilis* and Nazarudin (2012) in *Hibiscus rosa-sinensis*. Keever and Foster (1991) stated that growth retardants commonly used in floriculture for height suppression there by resulting in a larger number of inflorescences. The physiology behind the increase in number of sprays per plant may be described as increase in photosynthetic efficiency of leaves by increase in chlorophyll content of leaves, might accumulate more metabolites which increase the availability of reserve food for the reproductive growth (Vaghasia and Polara, 2005).

In the present experiment there is reduction in number of sprays per plant with application of ethephon compared to other growth retardants application. Similar results with ethephon application also found by Haque *et al.* in *Chrysanthemum cinerarifolium*,

#### **4.2.4 Number of flowers per stem**

The data regarding number of flowers per stem as influenced by different growth retardants is illustrated in Table 4.2.4 and Figure 4.2.4. There was significant difference observed among the different growth retardant treatments with respect to number of flowers per stem.

The maximum (37.66) number of flowers per stem was observed in daminozide 1000 ppm which was on par with daminozide 750 ppm (37.00) followed by daminozide 500 ppm (34.00) whereas minimum number of flowers per spray was observed in control (15.25) which was followed by ethephon 250 ppm (17.75).

From the above results it was evident that the daminozide treatments showed highest number of flowers per stem than untreated control plants. These results are in line with the findings of Ganesh (2014) in *Chrysanthemum*, Kazaz *et al.* (2010) in *Chrysanthemum morifolium*, Zakazewski (1989) in *Chrysanthemum grandiflorum*. Daminozide as a growth retardant inhibits the formation of highly active GAs from inactive precursors which block  $3\beta$  – hydroxylation in gibberellins biosynthesis (Rademacher, 2000). Dorajee rao (2012) stated that growth retardant treatments are useful, since they record high productivity because of their capacity to suppress vegetative growth, promote more buds to differentiate in to flower buds.

The reduction in number of flowers per stem by the application of ethephon was also reported by Banon *et al.* (2003) in *Reichardia tingitana*.

#### **4.2.5 Number of flowers per plant**

The data regarding number of flowers per plant as influenced by the different growth retardant treatments was illustrated in Table 4.2.5 and Figure 4.2.5. There was significant difference observed among various growth retardant treatments with respect to number of flowers per plant.

The maximum number of flowers per plant was observed in daminozide 1000 ppm (217.25) which was on par with daminozide 750 ppm (215.91) whereas minimum (86.39) number of flowers per plant was observed with control which was on par with ethephon 250 ppm (95.99).

From the above results it is evident that the maximum number of flowers per plant was recorded in daminozide at 1000 and 750 ppm treated plants when compared to control plants and other growth retardant treatments. These results are in parallel with the earlier findings of Joanna Krause (2003) in Marigold. Vaghasia and Polara (2008) stated that the application of growth retardants produces more number of branches which accumulates more carbohydrates through photosynthesis and were directly used for increase in number of flowers and flower yield. Increase in number of flowers per plant with the application of daminozide was also reported by

Wilfert and Barrett (1994) in *Rhododendron obtusum*, Kazemi (2014) in pot marigold.

In the present study there was decrease in number of flowers per plant with application of ethephon which might be due to minimum growth suppression with the chemical there by resulting in low availability of photosynthates in turn resulted less number of flowers per plant. Similar result with application of ethephon was also observed by Starman and Williams (2000) in *Scaevola aemula*.

#### **4.2.6 Peduncle length (cm)**

The data pertaining to peduncle length as affected by various growth retardants was illustrated in Table 4.2.6. Peduncle length was significantly affected by different growth retardants.

The maximum peduncle length was observed in daminozide 500 ppm (6.91 cm) which was on par with daminozide 750 ppm (6.76 cm) followed by daminozide 1000 ppm (5.70 cm) whereas minimum peduncle length was observed with paclobutrazol 60 ppm (0.52 cm) which was on par with paclobutrazol 30 ppm (0.74 cm), paclobutrazol 90 ppm (0.75 cm), uniconazole 16 ppm (0.88 cm), uniconazole 8 ppm (1.05 cm).

In the present investigation, peduncle length was increased with application of daminozide treatments which could be attributed to moderate reduction of plant growth. Similar result was also found by Wang and Hsu (1994) in *Phalaenopsis* Orchids. Christiana *et al.* (2005) stated that the daminozide promotes translocation of photosynthates to the inflorescences thus improves plant quality which attributed to restriction in gibberellins.

From the above results it was evident that paclobutrazol treatment highly reduced the peduncle length of potmums when compared to control and other growth retardant treatments. Similar retarding effects of paclobutrazol on peduncle length were reported for other plant species (Gilbertz, 1992) in *Dendranthema*

*grandiflora*, Harry (1990) in *Pelargonium hortorum*, Starman and Williams (2000) in *Scaevola aemula*, Burner (2001) in Canna Lily. Ecker (1992) stated that the application of paclobutrazol as substrate drench alters the entire plant morphology and structure of foliage and inflorescence to a thicker and more compact nature.

#### **4.2.7 Diameter of the Flower (cm)**

The data pertaining to diameter of the flower as affected by different growth retardants was illustrated in Table 4.2.7 and Fig.4.2.7. Flower diameter was significantly affected by different growth retardant treatments.

The maximum was observed with ethephon 1000 ppm (3.98 cm) which was on par with ethephon 500 ppm (3.93 cm) followed by daminozide 750 ppm (3.81 cm) and minimum was observed with paclobutrazol 30 ppm (2.67 cm) which was on par with paclobutrazol 90 ppm (2.67 cm) and paclobutrazol 60 ppm (2.78 cm), uniconazole 4 ppm (2.77 cm).

From the above results it is evident that the flower diameter was highly increased in ethephon treatments of 1000 ppm followed by 500 ppm compared to control. The increase in flower diameter was brought about through the accumulation of higher percentage of dry matter in to the flowers with increase in lateral branching. Similar results of increased flower diameter with ethephon were also recorded by Chen (2002) in *Gynura aurantiaca*, Haque *et al.* (2007) in *Chrysanthemum cinerarifolium* and Harry *et al.* (1990) in *Pelargonium hortorum*, Currey and Erwin (2012) in *Kalanchoe rosei*. The effects of growth inhibitors operate at the level of cell elongation, dry matter accumulation, stem elongation and other floral characteristics (Stefanini *et al.* 2002).

The decrease in flower diameter by the application of paclobutrazol was observed by Haque *et al.* (2007) in *Chrysanthemum cinerarifolium* and Ecker (1992) in *Matthiola incana* which was attributed to its dwarfing effect. Paclobutrazol reduces plant height, increases the main and secondary branching there by increasing the flower number with reduction in flower diameter (Hensel, 1985).

#### **4.2.8 Flower weight (g)**

The data enunciated on flower weight in pot mums as influenced by various growth retardant treatments was presented in the Table 4.2.8 and Figure 4.2.8. Significant difference in individual flower weight was noticed among the treatments having various concentrations of growth retardants.

The maximum weight of the flower was recorded in ethephon 1000 ppm (1.46 g) which was on par with daminozide 750 ppm (1.15 g), daminozide 500 ppm (1.34 g), daminozide 1000 ppm (1.18 g), uniconazole 4 ppm (1.31 g) compared to control (0.87 g) whereas minimum weight of the flower was recorded in paclobutrazol 60 ppm (0.72 g) which was on par with uniconazole 16 ppm (0.83 g), paclobutrazol 90 ppm (0.85 g), control (0.87 g).

From the above results it was evident that ethephon and daminozide treatments increased the weight of the flower when compared to control. The increase in flower weight was due increased mobilization of biomass to flowers from source due to dwarfing effect of growth retardants which resulted in highest flower weight (Lokhande *et al.*, 2008). These results are in proximity with Haque *et al.* (2007) in *Chrysanthemum cinerarifolium*, Harry *et al.* (1990) in *Pelargonium hortorum* by ethephon treatment and Christiana (2005) in *Zinnia elegans*, Kazaz (2010) in *Chrysanthemum morifolium* in daminozide treatment.

#### **4.2.9 Duration of the flowering (days)**

The data recorded on duration of flowering in potmums as influenced by various growth retardants was illustrated in Table 4.2.9 and Figure 4.2.9. There was significant difference among the various treatments with respect to the duration of flowering.

The maximum duration of flowering was recorded in daminozide 1000 ppm (68.00 days) which was on par with daminozide 750 ppm (67.67 days), daminozide

500 ppm (67.50 days), uniconazole 16 ppm (66.17 days), uniconazole 8 ppm (64.50 days) whereas minimum duration of flowering was recorded in ethephon 1000 ppm (50.5 days), ethephon 750 ppm (50.83 days), ethephon 500 ppm (51.50 days).

From the above results it was evident that the daminozide treatments showed highest duration of flowering. These results are in line with the findings of Kazaz *et al.* (2010) in *Chrysanthemum morifolium*. Daminozide reduces translocation of gibberellic acid to actively growing area which in turn promotes reduction in growth and translocation of carbohydrates to inflorescences (Christana, 2005). Similar results were obtained by Kazemi *et al.* (2014) in *Calendula officinalis*.

#### **4.2.10 Vase life (days)**

Data recorded on vase life in chrysanthemum potmums as influenced by various concentrations of growth retardants was presented in Table 4.2.10. Significant difference in vase life of flowers was observed among the different treatments of growth retardants.

The maximum vase life of flowers was observed with daminozide 500 ppm (16.33 days) which was on par with daminozide 750 ppm (15.33 days) whereas minimum vase life was recorded in ethephon 750 ppm (9.00 days) which was on par with ethephon 500 ppm (9.17 days), ethephon 250 ppm (9.50 days) followed by control (10.50 days).

The increase in vase life of flowers by the application of daminozide was also observed by Kahar (2008) in *Chrysanthemum*. Ganesh (2014) stated that the increase in vase life of flowers could be attributed to internal physiological status of the stems delaying early onset of the senescence and improvement in water relations, hydraulic conductance, carbohydrates which prevented vascular blockage and increased the vase life. Longest vase life might be due to fact that growth retardants reduce the cell size there by stomatal size and hence the reduction in area of transpiration which might have resulted in better water balance (Sujatha *et al.*

2002) similar effect of enhanced vase life by the application of daminozide was also reported by Patil (2013) in China Aster.

Similar reduction in vase life by the application of ethephon also reported by Van Doorn *et al.* (2011) in Cut Tulips (*Tulipa* spp.) and stated that the application of ethephon limits vase life of flowers by a combination of tepal senescence and tepal abscission.

**Table 4.1.1 Effect of growth retardants on Plant height of  
Chrysanthemum potmums (*Dendranthema grandiflora*)**

<b>Treatment (T)</b>	<b>Plant Height (cm)</b>
(T <sub>1</sub> ) Paclobutrazol 30ppm	18.58
(T <sub>2</sub> ) Paclobutrazol 60ppm	17.42
(T <sub>3</sub> ) Paclobutrazol 90ppm	16.92
(T <sub>4</sub> ) Daminozide 500 ppm	24.92
(T <sub>5</sub> ) Daminozide 750 ppm	27.00
(T <sub>6</sub> ) Daminozide 1000 ppm	24.25
(T <sub>7</sub> ) Ethephon 250 ppm	36.75
(T <sub>8</sub> ) Ethephon 500 ppm	35.58
(T <sub>9</sub> ) Ethephon 750 ppm	34.00
(T <sub>10</sub> ) Ethephon 1000ppm	32.67
(T <sub>11</sub> ) Uniconazole 4ppm	26.17
(T <sub>12</sub> ) Uniconazole 8ppm	22.50
(T <sub>13</sub> ) Uniconazole 16 ppm	18.33
(T <sub>14</sub> ) Control	47.06
<b>S.Em. ±</b>	0.78
<b>C.D at 5%</b>	2.26
<b>F Test</b>	<b>**</b>

**Table 4.1.2 Effect of growth retardants on Number of primary branches of Chrysanthemum pot mums (*Dendranthema grandiflora*)**

<b>Treatment (T)</b>	<b>Number of primary branches</b>
T <sub>1</sub> - Paclobutrazol 30ppm	7.83
T <sub>2</sub> - Paclobutrazol 60ppm	6.25
T <sub>3</sub> - Paclobutrazol 90ppm	6.75
T <sub>4</sub> - Daminozide 500 ppm	6.08
T <sub>5</sub> - Daminozide 750 ppm	6.75
T <sub>6</sub> - Daminozide 1000 ppm	7.16
T <sub>7</sub> - Ethephon 250 ppm	6.41
T <sub>8</sub> - Ethephon 500 ppm	6.50
T <sub>9</sub> - Ethephon 750 ppm	7.75
T <sub>10</sub> - Ethephon 1000ppm	6.25
T <sub>11</sub> -Uniconazole 4ppm	6.50
T <sub>12</sub> -Uniconazole 8ppm	7.16
T <sub>13</sub> -Uniconazole 16 ppm	6.25
T <sub>14</sub> – Control	6.33
<b>S.Em. ±</b>	0.24
<b>C.D at 5%</b>	0.69
<b>F test</b>	**

**Table 4.1.3 Effect of growth retardants on Internodal length of *Chrysanthemum potmums (Dendranthema grandiflora)***

<b>Treatment (T)</b>	<b>Internodal length (cm)</b>
(T <sub>1</sub> ) Paclobutrazol 30ppm	0.54
(T <sub>2</sub> ) Paclobutrazol 60ppm	0.50
(T <sub>3</sub> ) Paclobutrazol 90ppm	0.53
(T <sub>4</sub> ) Daminozide 500 ppm	0.87
(T <sub>5</sub> ) Daminozide 750 ppm	0.96
(T <sub>6</sub> ) Daminozide 1000 ppm	0.86
(T <sub>7</sub> ) Ethephon 250 ppm	1.20
(T <sub>8</sub> ) Ethephon 500 ppm	1.37
(T <sub>9</sub> ) Ethephon 750 ppm	1.15
(T <sub>10</sub> ) Ethephon 1000ppm	1.33
(T <sub>11</sub> ) Uniconazole 4ppm	0.95
(T <sub>12</sub> ) Uniconazole 8ppm	0.85
(T <sub>13</sub> ) Uniconazole 16 ppm	0.50
(T <sub>14</sub> ) Control	2.55
<b>S.Em. ±</b>	0.07
<b>C.D at 5%</b>	0.21
<b>F Test</b>	**

**Table 4.1.4.1 Effect of growth retardants on Plant spread (E-W)  
Of Chrysanthemum potmums (*Dendranthema grandiflora*)**

<b>Treatment (T)</b>	<b>Plant spread E-W (cm)</b>
(T <sub>1</sub> ) Paclobutrazol 30ppm	20.17
(T <sub>2</sub> ) Paclobutrazol 60ppm	22.83
(T <sub>3</sub> ) Paclobutrazol 90ppm	19.42
(T <sub>4</sub> ) Daminozide 500 ppm	30.83
(T <sub>5</sub> ) Daminozide 750 ppm	34.17
(T <sub>6</sub> ) Daminozide 1000 ppm	32.75
(T <sub>7</sub> ) Ethephon 250 ppm	45.58
(T <sub>8</sub> ) Ethephon 500 ppm	44.42
(T <sub>9</sub> ) Ethephon 750 ppm	48.67
(T <sub>10</sub> ) Ethephon 1000ppm	45.00
(T <sub>11</sub> ) Uniconazole 4ppm	29.17
(T <sub>12</sub> ) Uniconazole 8ppm	30.33
(T <sub>13</sub> ) Uniconazole 16 ppm	21.00
(T <sub>14</sub> ) Control	37.92
<b>S.Em. ±</b>	1.44
<b>C.D at 5%</b>	4.18
<b>F Test</b>	**

**Table 4.1.4.2 Effect of growth retardants on Plant spread (N-S)  
Of Chrysanthemum potmums (*Dendranthema grandiflora*)**

<b>Treatment (T)</b>	<b>Plant spread N - S (cm)</b>
(T <sub>1</sub> ) Paclobutrazol 30ppm	20.08
(T <sub>2</sub> ) Paclobutrazol 60ppm	19.50
(T <sub>3</sub> ) Paclobutrazol 90ppm	17.75
(T <sub>4</sub> ) Daminozide 500 ppm	33.17
(T <sub>5</sub> ) Daminozide 750 ppm	33.08
(T <sub>6</sub> ) Daminozide 1000 ppm	33.50
(T <sub>7</sub> ) Ethephon 250 ppm	53.17
(T <sub>8</sub> ) Ethephon 500 ppm	56.08
(T <sub>9</sub> ) Ethephon 750 ppm	55.42
(T <sub>10</sub> ) Ethephon 1000ppm	55.08
(T <sub>11</sub> ) Uniconazole 4ppm	27.67
(T <sub>12</sub> ) Uniconazole 8ppm	28.50
(T <sub>13</sub> ) Uniconazole 16 ppm	22.50
(T <sub>14</sub> ) Control	40.83
<b>S.Em. ±</b>	1.33
<b>C.D at 5%</b>	3.87
<b>F Test</b>	**

**Table 4.1.6. Effect of growth retardants on Leaf width of Chrysanthemum potmums (*Dendranthema grandiflora* )**

<b>Treatment</b>	<b>Leaf width (cm)</b>
(T <sub>1</sub> ) Paclobutrazol 30ppm	3.62
(T <sub>2</sub> ) Paclobutrazol 60ppm	3.81
(T <sub>3</sub> ) Paclobutrazol 90ppm	3.97
(T <sub>4</sub> ) Daminozide 500 ppm	3.60
(T <sub>5</sub> ) Daminozide 750 ppm	4.22
(T <sub>6</sub> ) Daminozide 1000 ppm	4.41
(T <sub>7</sub> ) Ethephon 250 ppm	3.38
(T <sub>8</sub> ) Ethephon 500 ppm	4.01
(T <sub>9</sub> ) Ethephon 750 ppm	3.69
(T <sub>10</sub> ) Ethephon 1000ppm	3.66
(T <sub>11</sub> ) Uniconazole 4ppm	4.24
(T <sub>12</sub> ) Uniconazole 8ppm	4.19
(T <sub>13</sub> ) Uniconazole 16 ppm	3.85
(T <sub>14</sub> ) Control	4.28
<b>S.Em. ±</b>	0.15
<b>C.D at 5%</b>	0.44
<b>F Test</b>	**

**Table 4.1.5. Effect of growth retardants on Leaf length of  
Chrysanthemum potmums (*Dendranthema grandiflora*)**

<b>Treatment</b>	<b>Leaf length (cm)</b>
(T <sub>1</sub> ) Paclobutrazol 30ppm	4.60
(T <sub>2</sub> ) Paclobutrazol 60ppm	4.39
(T <sub>3</sub> ) Paclobutrazol 90ppm	5.37
(T <sub>4</sub> ) Daminozide 500 ppm	5.37
(T <sub>5</sub> ) Daminozide 750 ppm	5.68
(T <sub>6</sub> ) Daminozide 1000 ppm	6.26
(T <sub>7</sub> ) Ethephon 250 ppm	4.69
(T <sub>8</sub> ) Ethephon 500 ppm	5.98
(T <sub>9</sub> ) Ethephon 750 ppm	5.27
(T <sub>10</sub> ) Ethephon 1000ppm	5.07
(T <sub>11</sub> ) Uniconazole 4ppm	5.16
(T <sub>12</sub> ) Uniconazole 8ppm	5.50
(T <sub>13</sub> ) Uniconazole 16 ppm	5.68
(T <sub>14</sub> ) Control	5.67
<b>S.Em. ±</b>	0.19
<b>C.D at 5%</b>	0.56
<b>F Test</b>	**

**Table 4.1.7. Effect of growth retardants on SCMR value of *Chrysanthemum potmums (Dendranthema grandiflora)***

<b>Treatment</b>	<b>SCMR Value</b>
(T <sub>1</sub> ) Paclobutrazol 30ppm	66.42
(T <sub>2</sub> ) Paclobutrazol 60ppm	73.25
(T <sub>3</sub> ) Paclobutrazol 90ppm	74.86
(T <sub>4</sub> ) Daminozide 500 ppm	59.47
(T <sub>5</sub> ) Daminozide 750 ppm	58.04
(T <sub>6</sub> ) Daminozide 1000 ppm	55.25
(T <sub>7</sub> ) Ethephon 250 ppm	47.90
(T <sub>8</sub> ) Ethephon 500 ppm	44.22
(T <sub>9</sub> ) Ethephon 750 ppm	39.87
(T <sub>10</sub> ) Ethephon 1000ppm	38.53
(T <sub>11</sub> ) Uniconazole 4ppm	57.92
(T <sub>12</sub> ) Uniconazole 8ppm	55.95
(T <sub>13</sub> ) Uniconazole 16 ppm	60.23
(T <sub>14</sub> ) Control	47.43
<b>S.Em. ±</b>	1.78
<b>C.D at 5%</b>	5.15
<b>F Test</b>	**

**Table 4.1.8. Effect of growth retardants on Diameter of the main stem of *Chrysanthemum potmums (Dendranthema grandiflora)***

<b>Treatment (T)</b>	<b>Diameter of the main stem (mm)</b>
(T <sub>1</sub> ) Paclobutrazol 30ppm	5.53
(T <sub>2</sub> ) Paclobutrazol 60ppm	5.66
(T <sub>3</sub> ) Paclobutrazol 90ppm	5.70
(T <sub>4</sub> ) Daminozide 500 ppm	6.39
(T <sub>5</sub> ) Daminozide 750 ppm	6.95
(T <sub>6</sub> ) Daminozide 1000 ppm	7.73
(T <sub>7</sub> ) Ethephon 250 ppm	6.18
(T <sub>8</sub> ) Ethephon 500 ppm	6.44
(T <sub>9</sub> ) Ethephon 750 ppm	6.67
(T <sub>10</sub> ) Ethephon 1000ppm	6.85
(T <sub>11</sub> ) Uniconazole 4ppm	5.48
(T <sub>12</sub> ) Uniconazole 8ppm	5.71
(T <sub>13</sub> ) Uniconazole 16 ppm	5.86
(T <sub>14</sub> ) Control	4.50
<b>S.Em. ±</b>	0.12
<b>C.D at 5%</b>	0.36
<b>F Test</b>	**

**Table 4.2.1. Effect of growth retardants on Days to 1st flower bud appearance of *Chrysanthemum potmums* (*Dendranthema grandiflora*)**

<b>Treatment</b>	<b>Days to 1<sup>st</sup> flower bud appearance</b>
(T <sub>1</sub> ) Paclobutrazol 30ppm	78.50
(T <sub>2</sub> ) Paclobutrazol 60ppm	78.00
(T <sub>3</sub> ) Paclobutrazol 90ppm	76.42
(T <sub>4</sub> ) Daminozide 500 ppm	78.5
(T <sub>5</sub> ) Daminozide 750 ppm	77.33
(T <sub>6</sub> ) Daminozide 1000 ppm	75.17
(T <sub>7</sub> ) Ethephon 250 ppm	88.42
(T <sub>8</sub> ) Ethephon 500 ppm	88.67
(T <sub>9</sub> ) Ethephon 750 ppm	86.50
(T <sub>10</sub> ) Ethephon 1000ppm	89.00
(T <sub>11</sub> ) Uniconazole 4ppm	81.00
(T <sub>12</sub> ) Uniconazole 8ppm	78.67
(T <sub>13</sub> ) Uniconazole 16 ppm	77.33
(T <sub>14</sub> ) Control	84.50
<b>S.Em. ±</b>	0.39
<b>C.D at 5%</b>	1.13
<b>F Test</b>	**

**Table 4.2.2. Effect of growth retardants on Days taken to 50% flowering of Chrysanthemum potmums (*Dendranthema grandiflora*)**

<b>Treatment</b>	<b>Days to 50% flowering</b>
(T <sub>1</sub> ) Paclobutrazol 30ppm	113.20
(T <sub>2</sub> ) Paclobutrazol 60ppm	112.50
(T <sub>3</sub> ) Paclobutrazol 90ppm	111.80
(T <sub>4</sub> ) Daminozide 500 ppm	104.70
(T <sub>5</sub> ) Daminozide 750 ppm	100.00
(T <sub>6</sub> ) Daminozide 1000 ppm	100.00
(T <sub>7</sub> ) Ethephon 250 ppm	127.30
(T <sub>8</sub> ) Ethephon 500 ppm	126.70
(T <sub>9</sub> ) Ethephon 750 ppm	125.00
(T <sub>10</sub> ) Ethephon 1000ppm	124.00
(T <sub>11</sub> ) Uniconazole 4ppm	115.00
(T <sub>12</sub> ) Uniconazole 8ppm	112.30
(T <sub>13</sub> ) Uniconazole 16 ppm	111.30
(T <sub>14</sub> ) Control	121.30
<b>S.Em. ±</b>	0.80
<b>C.D at 5%</b>	2.31
<b>F Test</b>	**

**Table 4.2.3. Effect of growth retardants on No. of flower stems per plant of Chrysanthemum potmums (*Dendranthema grandiflora*)**

<b>Treatment</b>	<b>No. of flower stems per plant</b>
(T <sub>1</sub> ) Paclobutrazol 30ppm	5.58
(T <sub>2</sub> ) Paclobutrazol 60ppm	5.83
(T <sub>3</sub> ) Paclobutrazol 90ppm	6.08
(T <sub>4</sub> ) Daminozide 500 ppm	6.16
(T <sub>5</sub> ) Daminozide 750 ppm	5.83
(T <sub>6</sub> ) Daminozide 1000 ppm	5.75
(T <sub>7</sub> ) Ethephon 250 ppm	5.41
(T <sub>8</sub> ) Ethephon 500 ppm	5.41
(T <sub>9</sub> ) Ethephon 750 ppm	5.83
(T <sub>10</sub> ) Ethephon 1000ppm	5.33
(T <sub>11</sub> ) Uniconazole 4ppm	6.33
(T <sub>12</sub> ) Uniconazole 8ppm	6.83
(T <sub>13</sub> ) Uniconazole 16 ppm	6.25
(T <sub>14</sub> ) Control	5.66
<b>S.Em. ±</b>	0.20
<b>C.D at 5%</b>	0.60
<b>F Test</b>	**

**Table 4.2.4 Effect of plant growth retardants on Number of flowers per stem of Chrysanthemum potmums (*Dendranthema grandiflora*)**

<b>Treatment</b>	<b>Number of Flowers per stem</b>
(T <sub>1</sub> ) Paclobutrazol 30ppm	23.16
(T <sub>2</sub> ) Paclobutrazol 60ppm	24.16
(T <sub>3</sub> ) Paclobutrazol 90ppm	23.16
(T <sub>4</sub> ) Daminozide 500 ppm	34.00
(T <sub>5</sub> ) Daminozide 750 ppm	37.00
(T <sub>6</sub> ) Daminozide 1000 ppm	37.66
(T <sub>7</sub> ) Ethephon 250 ppm	17.75
(T <sub>8</sub> ) Ethephon 500 ppm	18.66
(T <sub>9</sub> ) Ethephon 750 ppm	17.83
(T <sub>10</sub> ) Ethephon 1000ppm	19.41
(T <sub>11</sub> ) Uniconazole 4ppm	22.83
(T <sub>12</sub> ) Uniconazole 8ppm	21.50
(T <sub>13</sub> ) Uniconazole 16 ppm	20.50
(T <sub>14</sub> ) Control	15.25
<b>S.Em. ±</b>	0.76
<b>C.D at 5%</b>	2.20
<b>F Test</b>	**

**Table 4.2.5 Effect of growth retardants on Number of flowers per plant of Chrysanthemum potmums (*Dendranthema grandiflora*)**

<b>Treatment</b>	<b>Number of Flowers per plant</b>
(T <sub>1</sub> ) Paclobutrazol 30ppm	129.54
(T <sub>2</sub> ) Paclobutrazol 60ppm	140.87
(T <sub>3</sub> ) Paclobutrazol 90ppm	140.95
(T <sub>4</sub> ) Daminozide 500 ppm	210.21
(T <sub>5</sub> ) Daminozide 750 ppm	215.91
(T <sub>6</sub> ) Daminozide 1000 ppm	217.25
(T <sub>7</sub> ) Ethephon 250 ppm	95.99
(T <sub>8</sub> ) Ethephon 500 ppm	101.08
(T <sub>9</sub> ) Ethephon 750 ppm	104.04
(T <sub>10</sub> ) Ethephon 1000ppm	103.56
(T <sub>11</sub> ) Uniconazole 4ppm	144.50
(T <sub>12</sub> ) Uniconazole 8ppm	146.83
(T <sub>13</sub> ) Uniconazole 16 ppm	128.20
(T <sub>14</sub> ) Control	86.39
<b>S.Em. ±</b>	8.44
<b>C.D at 5%</b>	24.45
<b>F Test</b>	**

**Table 4.2.6 Effect of growth retardants on Peduncle length of  
Chrysanthemum potmums (*Dendranthema grandiflora* )**

<b>Treatment</b>	<b>Peduncle length (cm)</b>
(T <sub>1</sub> ) Paclobutrazol 30ppm	0.74
(T <sub>2</sub> ) Paclobutrazol 60ppm	0.52
(T <sub>3</sub> ) Paclobutrazol 90ppm	0.75
(T <sub>4</sub> ) Daminozide 500 ppm	6.91
(T <sub>5</sub> ) Daminozide 750 ppm	6.76
(T <sub>6</sub> ) Daminozide 1000 ppm	5.70
(T <sub>7</sub> ) Ethephon 250 ppm	4.31
(T <sub>8</sub> ) Ethephon 500 ppm	3.76
(T <sub>9</sub> ) Ethephon 750 ppm	3.43
(T <sub>10</sub> ) Ethephon 1000ppm	3.03
(T <sub>11</sub> ) Uniconazole 4ppm	1.58
(T <sub>12</sub> ) Uniconazole 8ppm	1.05
(T <sub>13</sub> ) Uniconazole 16 ppm	0.88
(T <sub>14</sub> ) Control	4.08
<b>S.Em. ±</b>	0.19
<b>C.D at 5%</b>	0.55
<b>F Test</b>	<b>**</b>

**Table 4.2.7 Effect of growth retardants on Diameter of the flower of *Chrysanthemum potmums (Dendranthema grandiflora)***

<b>Treatment</b>	<b>Flower diameter(cm)</b>
(T <sub>1</sub> ) Paclobutrazol 30ppm	2.67
(T <sub>2</sub> ) Paclobutrazol 60ppm	2.78
(T <sub>3</sub> ) Paclobutrazol 90ppm	2.67
(T <sub>4</sub> ) Daminozide 500 ppm	3.77
(T <sub>5</sub> ) Daminozide 750 ppm	3.81
(T <sub>6</sub> ) Daminozide 1000 ppm	3.78
(T <sub>7</sub> ) Ethephon 250 ppm	3.75
(T <sub>8</sub> ) Ethephon 500 ppm	3.93
(T <sub>9</sub> ) Ethephon 750 ppm	3.78
(T <sub>10</sub> ) Ethephon 1000ppm	3.98
(T <sub>11</sub> ) Uniconazole 4ppm	2.77
(T <sub>12</sub> ) Uniconazole 8ppm	2.85
(T <sub>13</sub> ) Uniconazole 16 ppm	2.88
(T <sub>14</sub> ) Control	3.46
<b>S.Em. ±</b>	0.03
<b>C.D at 5%</b>	0.11
<b>F Test</b>	**

**Table 4.2.8 Effect of growth retardants on Flower weight of  
Chrysanthemum potmums (*Dendranthema grandiflora*)**

<b>Treatment</b>	<b>Flower weight (g)</b>
(T <sub>1</sub> ) Paclobutrazol 30ppm	0.93
(T <sub>2</sub> ) Paclobutrazol 60ppm	0.72
(T <sub>3</sub> ) Paclobutrazol 90ppm	0.85
(T <sub>4</sub> ) Daminozide 500 ppm	1.34
(T <sub>5</sub> ) Daminozide 750 ppm	1.45
(T <sub>6</sub> ) Daminozide 1000 ppm	1.18
(T <sub>7</sub> ) Ethephon 250 ppm	0.97
(T <sub>8</sub> ) Ethephon 500 ppm	0.91
(T <sub>9</sub> ) Ethephon 750 ppm	1.15
(T <sub>10</sub> ) Ethephon 1000ppm	1.46
(T <sub>11</sub> ) Uniconazole 4ppm	1.31
(T <sub>12</sub> ) Uniconazole 8ppm	0.93
(T <sub>13</sub> ) Uniconazole 16 ppm	0.83
(T <sub>14</sub> ) Control	0.87
<b>S.Em. ±</b>	0.10
<b>C.D at 5%</b>	0.30
<b>F Test</b>	**

**Table 4.2.9 Effect of growth retardants on Duration of flowering of Chrysanthemum potmums (*Dendranthema grandiflora*)**

<b>Treatment</b>	<b>Duration of flowering</b>
(T <sub>1</sub> ) Paclobutrazol 30ppm	60.17
(T <sub>2</sub> ) Paclobutrazol 60ppm	60.33
(T <sub>3</sub> ) Paclobutrazol 90ppm	60.67
(T <sub>4</sub> ) Daminozide 500 ppm	67.50
(T <sub>5</sub> ) Daminozide 750 ppm	67.67
(T <sub>6</sub> ) Daminozide 1000 ppm	68.00
(T <sub>7</sub> ) Ethephon 250 ppm	57.17
(T <sub>8</sub> ) Ethephon 500 ppm	51.50
(T <sub>9</sub> ) Ethephon 750 ppm	50.83
(T <sub>10</sub> ) Ethephon 1000ppm	50.50
(T <sub>11</sub> ) Uniconazole 4ppm	61.83
(T <sub>12</sub> ) Uniconazole 8ppm	64.50
(T <sub>13</sub> ) Uniconazole 16 ppm	66.17
(T <sub>14</sub> ) Control	56.83
<b>S.Em. ±</b>	1.32
<b>C.D at 5%</b>	3.85
<b>F Test</b>	**

**4.2.10 Effect of growth retardants on Vase life of Chrysanthemum  
potmums (*Dendranthema grandiflora*)**

<b>Treatment</b>	<b>Vase life(days)</b>
(T <sub>1</sub> ) Paclobutrazol 30ppm	12.00
(T <sub>2</sub> ) Paclobutrazol 60ppm	11.50
(T <sub>3</sub> ) Paclobutrazol 90ppm	12.50
(T <sub>4</sub> ) Daminozide 500 ppm	16.33
(T <sub>5</sub> ) Daminozide 750 ppm	15.33
(T <sub>6</sub> ) Daminozide 1000 ppm	14.50
(T <sub>7</sub> ) Ethephon 250 ppm	9.50
(T <sub>8</sub> ) Ethephon 500 ppm	9.17
(T <sub>9</sub> ) Ethephon 750 ppm	9.00
(T <sub>10</sub> ) Ethephon 1000ppm	9.42
(T <sub>11</sub> ) Uniconazole 4ppm	11.50
(T <sub>12</sub> ) Uniconazole 8ppm	12.50
(T <sub>13</sub> ) Uniconazole 16 ppm	13.50
(T <sub>14</sub> ) Control	10.50
<b>S.Em. ±</b>	0.37
<b>C.D at 5%</b>	1.09
<b>F Test</b>	**



**Plate 1: Nursery of chrysanthemum variety “HYDC – 9”**



**TITLE: IMPACT OF GROWTH RETARDANTS ON  
GROWTH AND FLOWERING OF POTMUMS**  
(*Dendrotheams grandiflora*)  
**DESIGN : CRD**  
**REPLICATIONS : 3**  
**NO. OF TREATMENTS: 14.**  
**DATE OF PLANTING: 01-08-2015**  
**NAME OF THE CHAIRMAN:**  
Dr. A.S. PADMAVATHANMA  
**NAME OF THE STUDENT:**  
B. SHAILAJA, RHM/14-18

**Plate 2: Overall view of experimental block**



**Plate 6: Plant height of Chrysanthemum pot mums treated with Ethephon**



**Plate 7: Plant height of Chrysanthemum pot mums treated with Uniconazole**



**Plate 8: Effect of different treatments on plant height of Chrysanthemum pot mums**



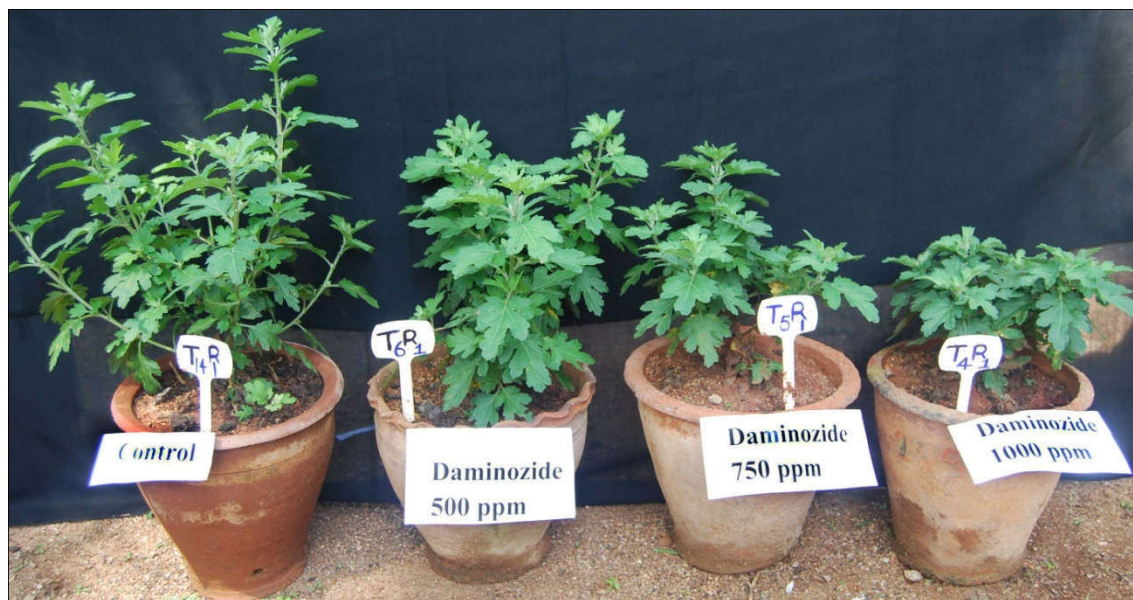
**Plate 9: Effect of Paclobutrazol on flowering of chrysanthemum potmums**



**Plate 10 : Effect of Daminozide on flowering of chrysanthemum potmums**



**Plate 3: Flowering stage of chrysanthemum potmums**



**Plate 4: Plant height of chrysanthemum pot mums treated with Daminozide**



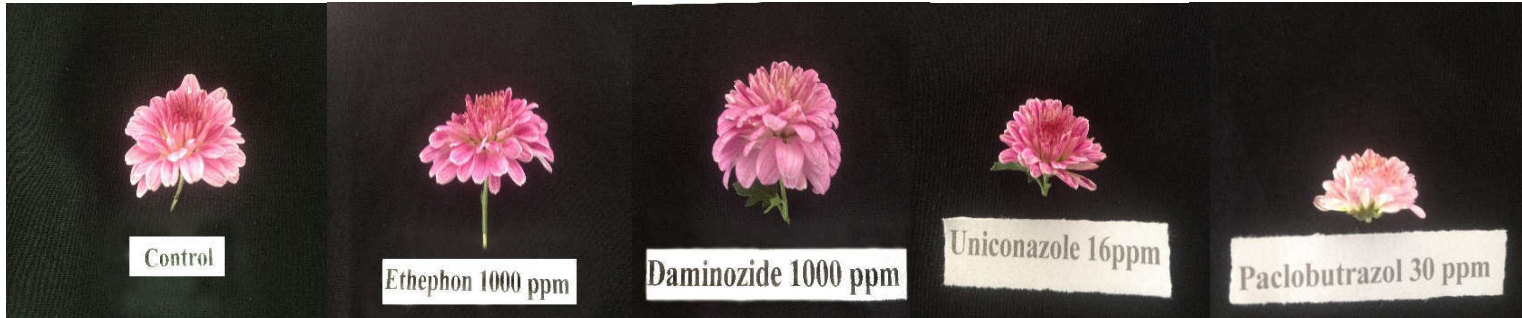
**Plate 5: Plant height of chrysanthemum pot mums treated with Paclobutrazol**



**Plate 11: Effect of Ethephon on flowering of Chrysanthemum**



**Plate 12: Effect of Uniconazole on flowering of Chrysanthemum**

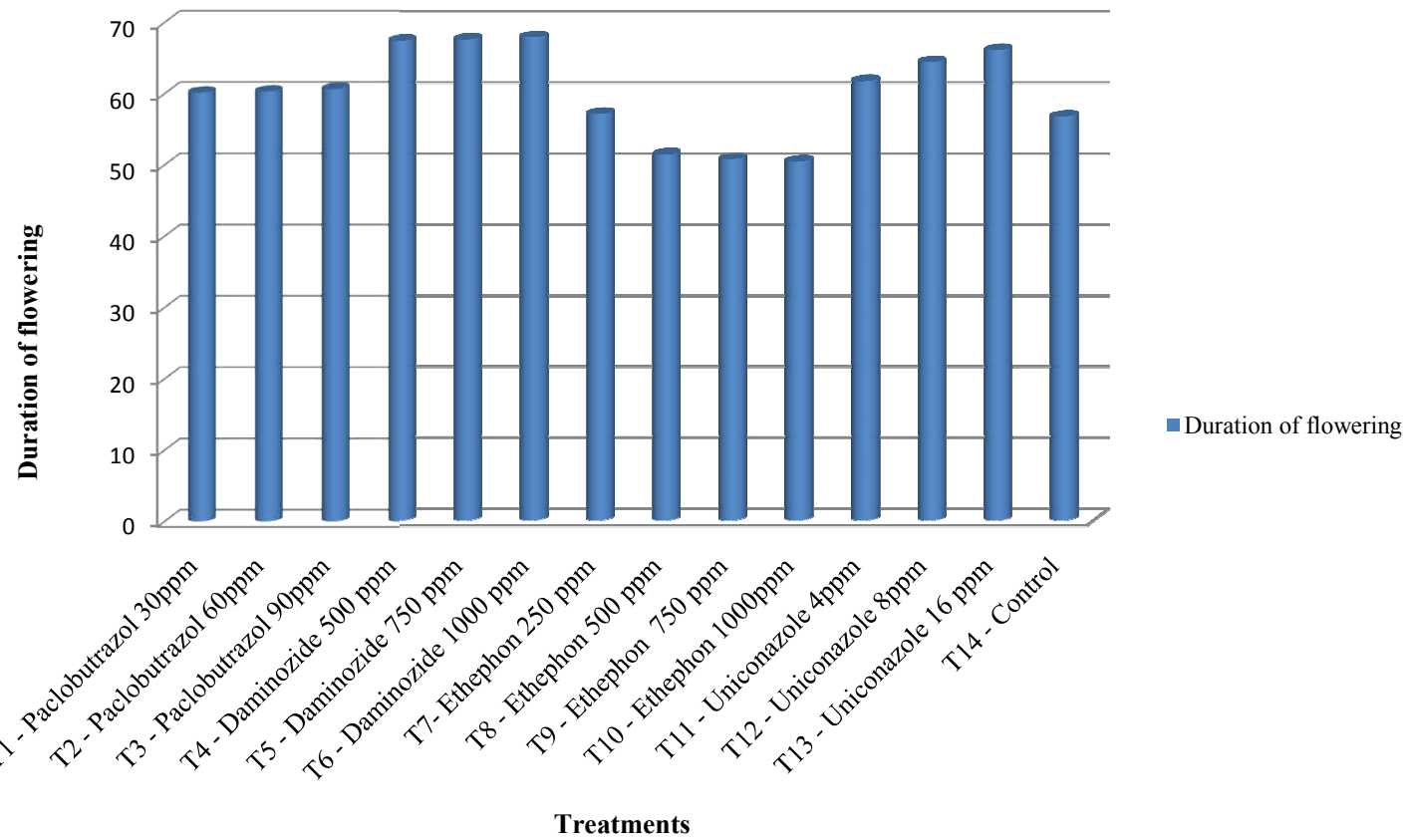


**Plate 13: Effect of growth retardants on Diameter of flower**

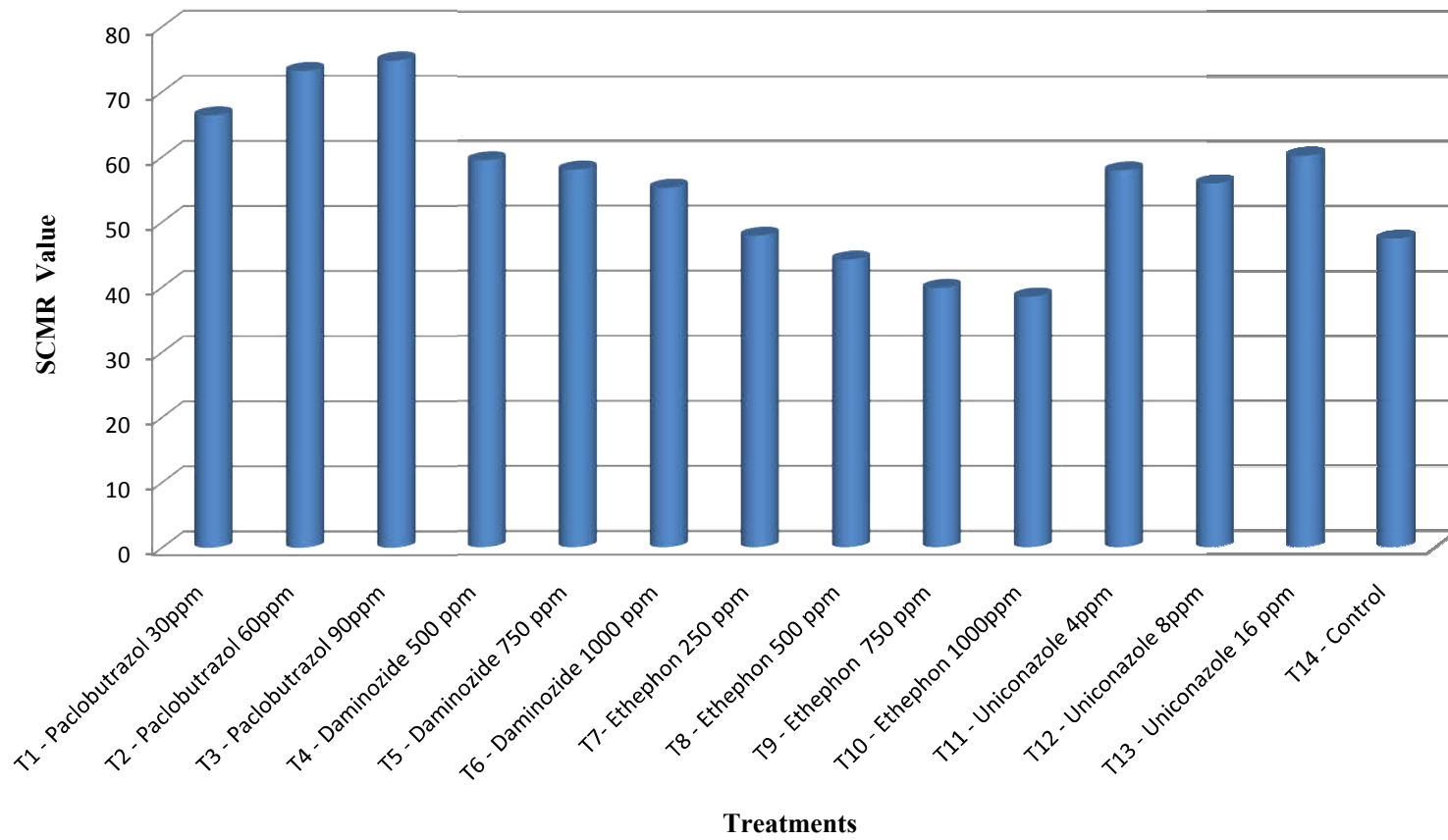


**Plate 14: Effect of growth retardants on Vase life**

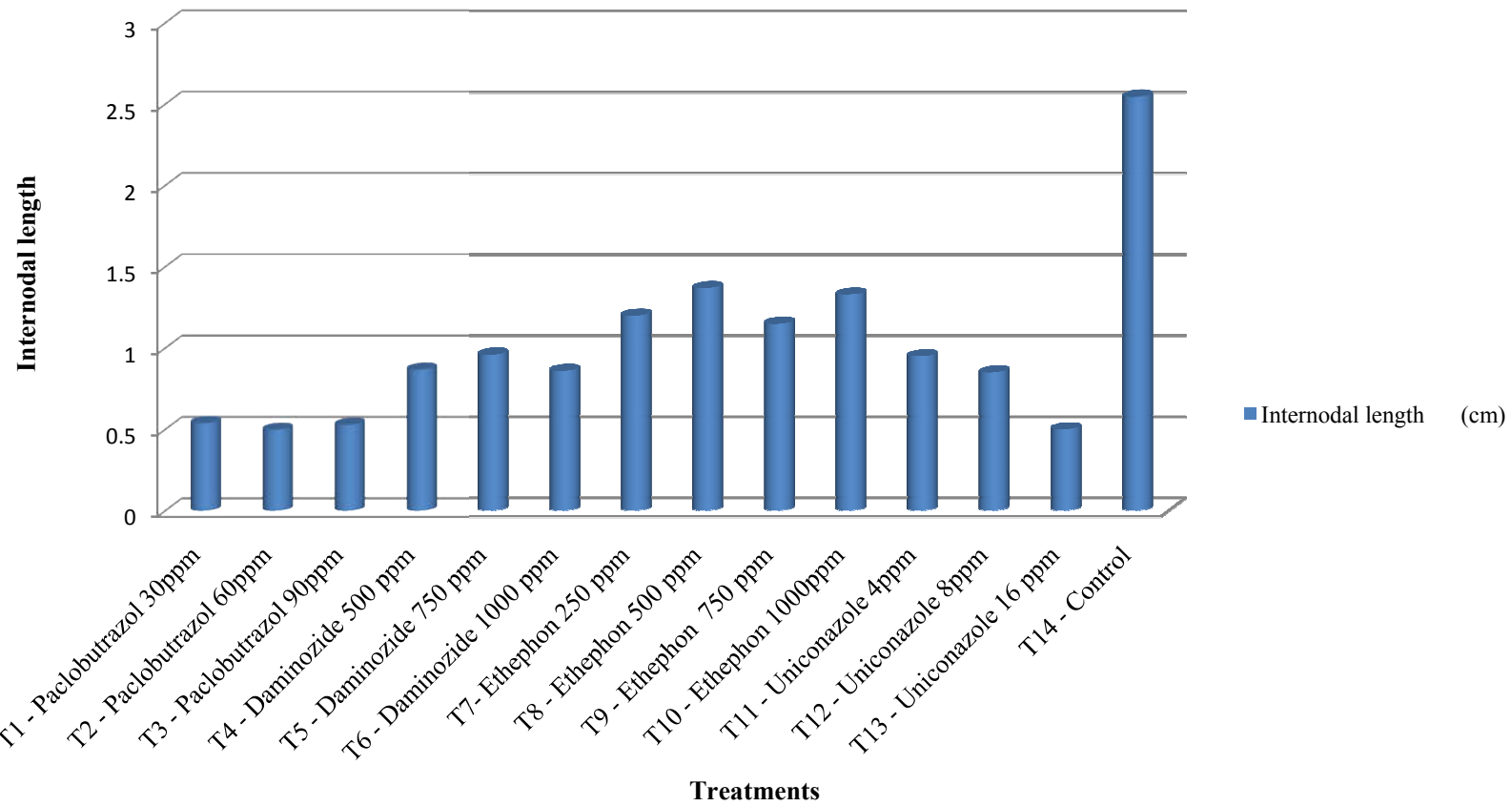
**Fig 4.2.9 Effect of growth retardants on Duration of flowering of Chrysanthemum Pot mums (*Dendranthema grandiflora*)**



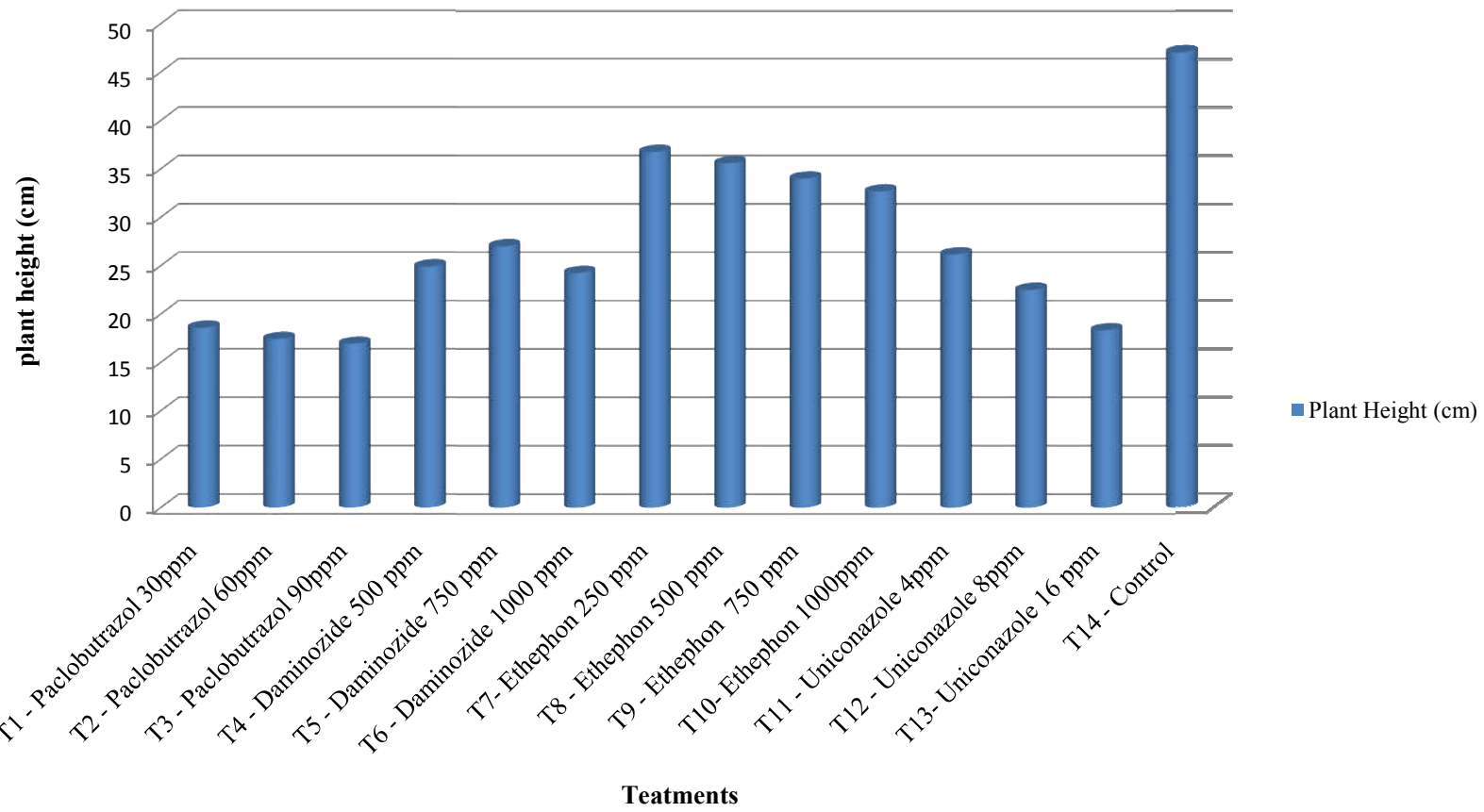
**Fig 4.1.7 Effect of growth retardants on SCMR value of *Chrysanthemum* Pot mums (*Dendranthema grandiflora*)**



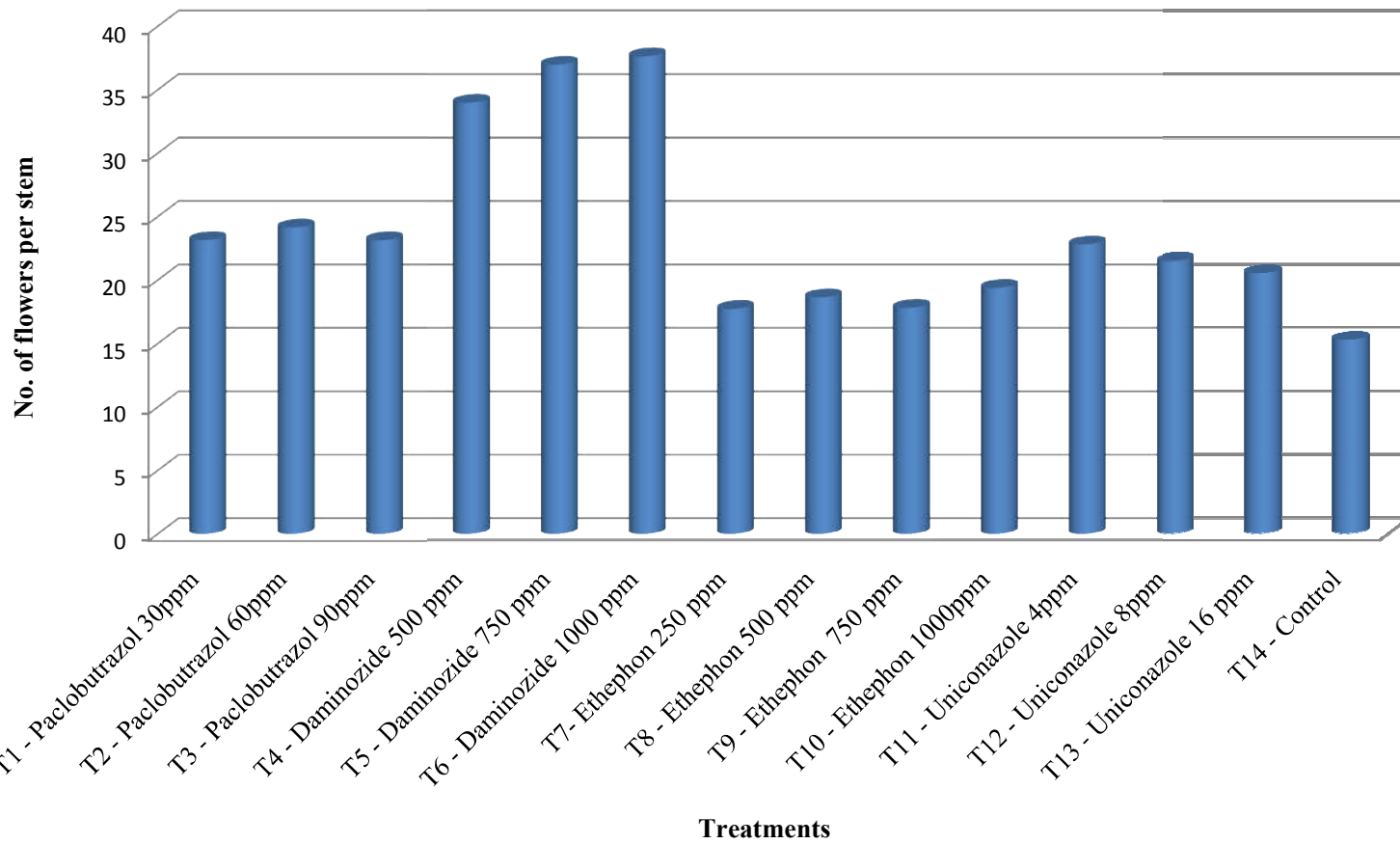
**Fig 4.1.3 Effect of growth retardants on Internodal length of Chrysanthemum Pot mums (*Dendranthema grandiflora*)**



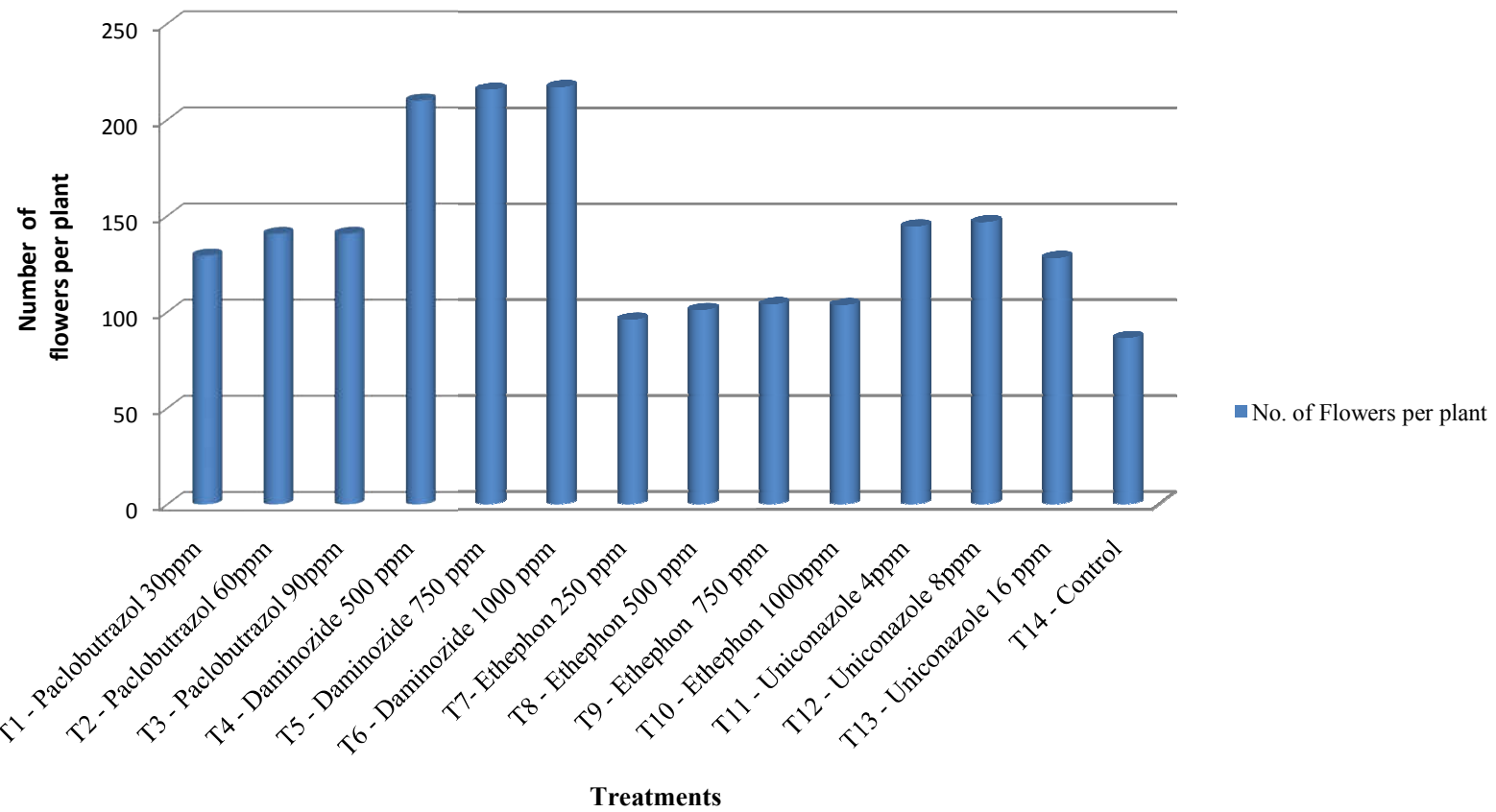
**Fig 4.1.1 Effect of growth retardants on Plant height (cm) of Chrysanthemum Pot mums (*Dendranthema grandiflora*)**



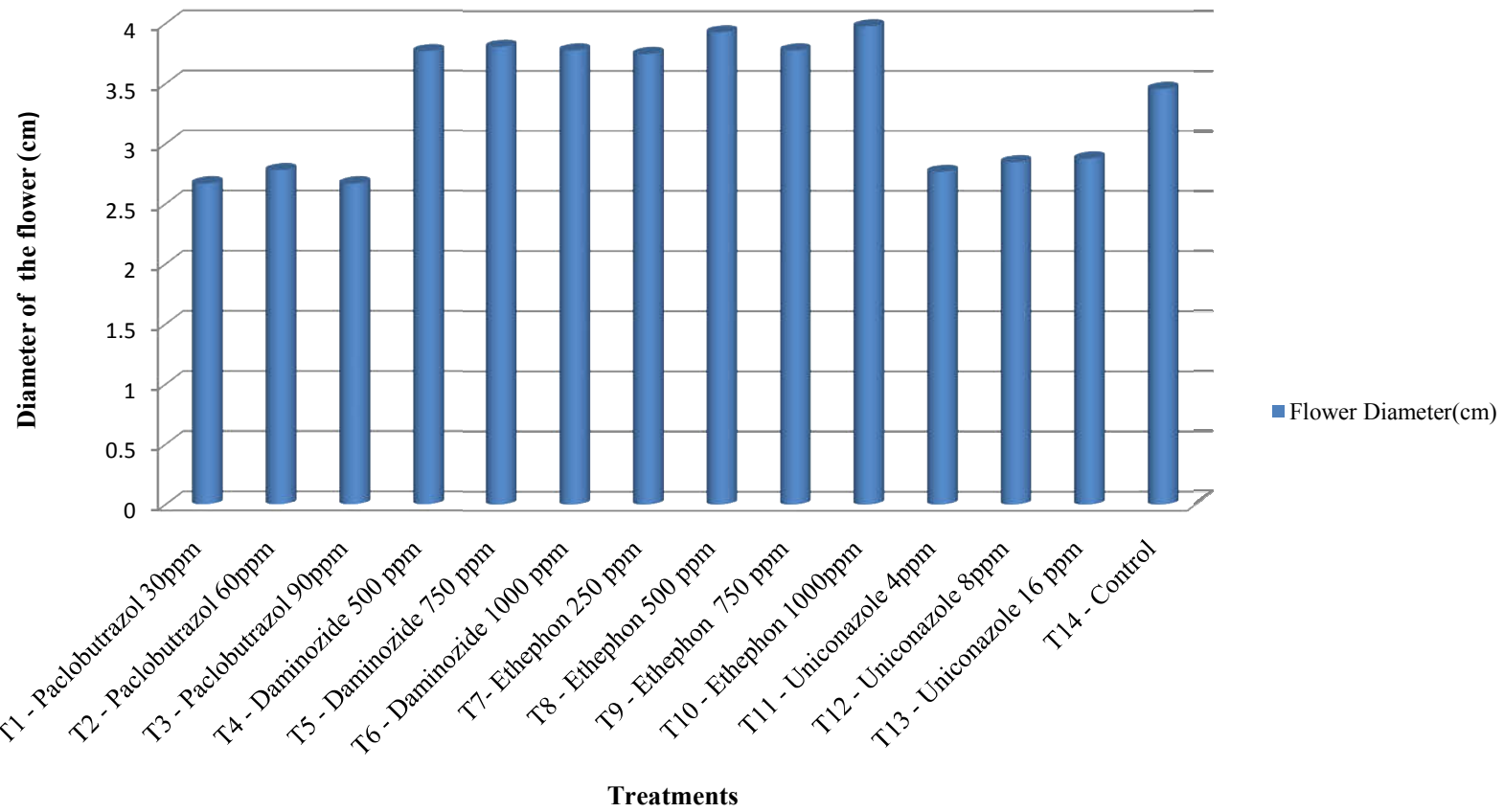
**Fig 4.2.4 Effect of growth retardants on Number of flowers per stem of Chrysanthemum  
Pot mums (*Dendranthema grandiflora*)**



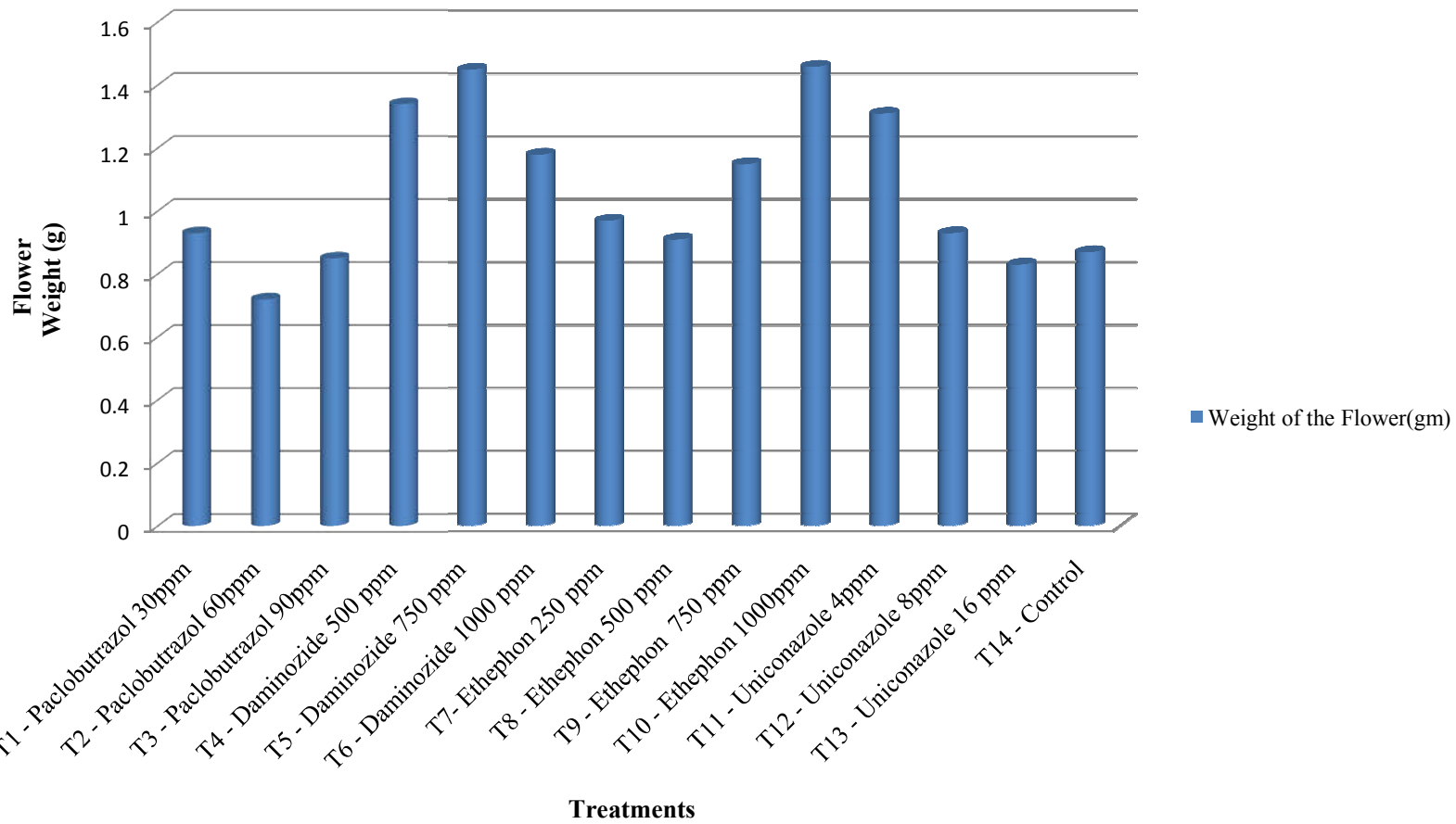
**Fig 4.2.5 Effect of growth retardants on Number of flowers per plant of Chrysanthemum Pot mums (*Dendranthema grandiflora*)**



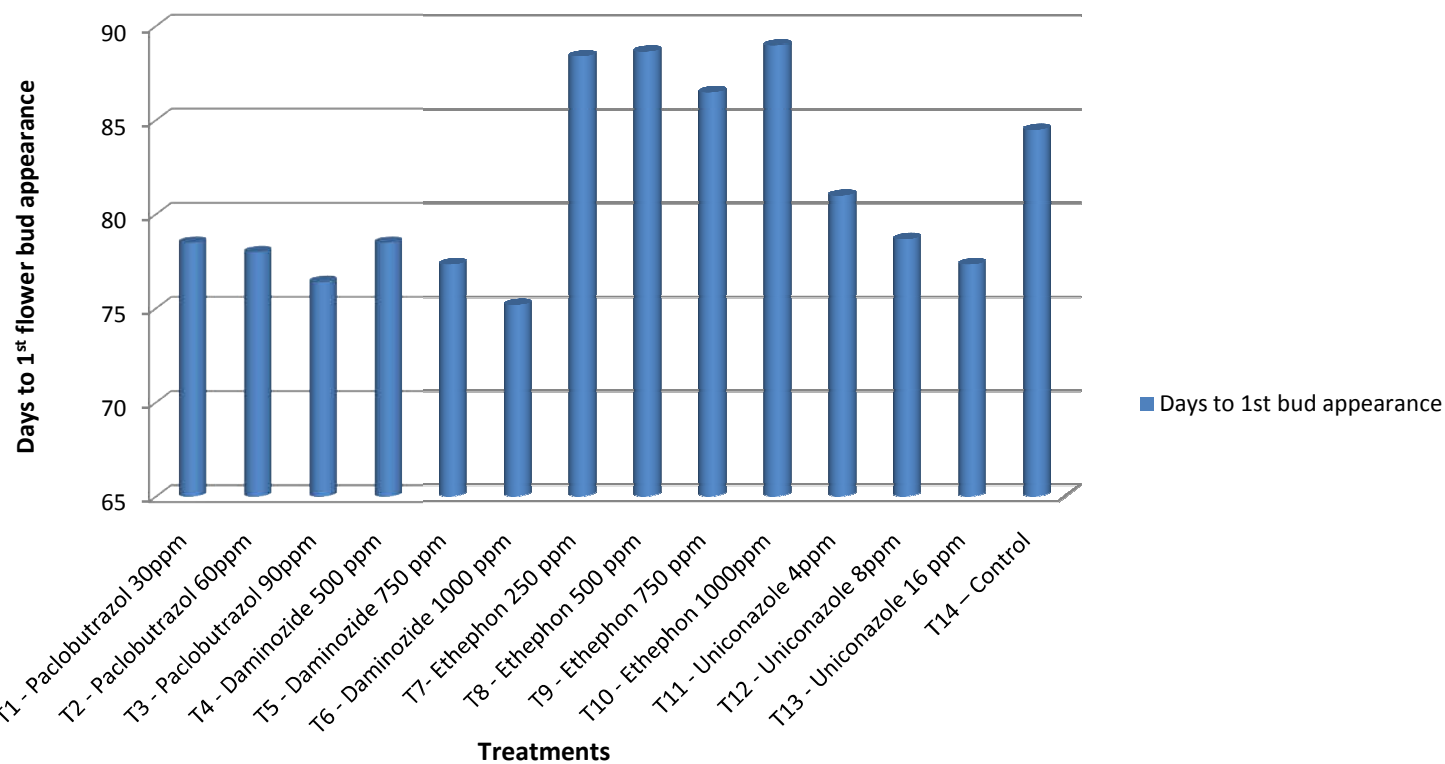
**Fig 4.2.7 Effect of growth retardants on Diameter of the flower (cm) of Chrysanthemum Pot mums (*Dendranthema grandiflora*)**



**Fig 4.2.8 Effect of growth retardants on Flower weight (g) of Chrysanthemum Pot mums (*Dendranthema grandiflora*)**



**Fig 4.2.9 Effect of growth retardants on Days to 1<sup>st</sup> flower bud appearance of Chrysanthemum Pot mums (*Dendranthema grandiflora*)**



## **CHAPTER-V**

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# **SUMMARY AND CONCLUSION**

## CHAPTER V

# SUMMARY AND CONCLUSION

A field experiment entitled “Impact of growth retardants on growth and floral characters of chrysanthemum potmums (*Dendranthema grandiflora*)” was carried out at floriculture research station, Rajendranagar, Hyderabad during the Rabi season of 2015-2016. The experiment was laid out in completely randomized design. In the present experiment an attempt has been made to determine the effect of different growth retardants on growth and floral characters of chrysanthemum potmums and salient features of the findings are summarized here under.

### **5.1 Effect of growth retardants on vegetative and floral characters of Chrysanthemum potmums**

- Maximum reduction in plant height (16.92 cm) and plant spread E-W (19.42 cm) and N-S (17.75 cm) were observed with application of paclobutrazol at 90 ppm whereas moderate reduction of plant height (24.25 cm) and plant spread E-W (32.75 cm) and N-S (33.50 cm) were achieved with application of daminozide at 1000 ppm.
- Maximum reduction in internodal length (0.50 cm) was achieved with paclobutrazol 60 ppm whereas moderate reduction (0.86 cm) was observed with application of daminozide at 1000 ppm.
- Maximum number of primary branches (7.83) was found with application of paclobutrazol at 30 ppm and was on par with ethephon 750 ppm.

- Maximum diameter of the main stem (7.73 mm), leaf length (6.26 cm) and leaf width (4.41 cm) were found with daminozide at 1000 ppm.
- Maximum Spad chlorophyll meter reading of 74.86 (SCMR value) was observed with application of paclobutrazol at 90 ppm and was on par with paclobutrazol 60 ppm.
- The early appearance of first floral bud (75.17 days) was found with application of daminozide at 1000 ppm followed by paclobutrazol 90 ppm and daminozide 750 ppm whereas delay in first floral bud appearance (89.00 days) was observed with the application of ethephon at 1000 ppm.
- Earliness in 50% flowering (100.00 days), maximum duration of flowering (68.00 days) were observed with application of daminozide at 1000 ppm and found to be on par with daminozide at 750 ppm.
- Maximum number of flowers per stem (37.66), maximum number of flowers per plant (217.25) were found with application of daminozide at 1000 ppm and was on par with daminozide 750 ppm.
- Maximum peduncle length (6.91 cm) was observed with application of @ daminozide 500 ppm which was on par with daminozide 750 ppm, whereas minimum peduncle length (0.52 cm) was observed with paclobutrazol 60 ppm.
- Maximum flower diameter (3.98 cm) and weight of the flower (1.46 g) was observed with application of ethephon at 1000 ppm.

- Longer vase life of flowers (16.33) was observed from plants treated with daminozide at 500 ppm which was on par with daminozide 750 ppm, whereas minimum vase life (9.00) was found with application of ethephon at 750 ppm.

## **CONCLUSION**

The moderate growth reduction and increased chlorophyll in Chrysanthemum potmums and earliness in flower bud appearance and 50% flowering, highest number of flowers per stem, simultaneously higher number of flowers per plant and duration of flowering were observed with application of daminozide @1000 ppm followed by application of daminozide @750 ppm. These were attributed to breakdown of gibberellin bio synthesis and suppression of vegetative growth which in turn promotes more buds to differentiate into flower buds with increased mobilization of photosynthates for flowering, which might have resulted in uniform growth and flowering producing attractive and higher quality of potted plants.

## **FUTURE LINE OF WORK**

- Further research can be done for testing the efficacy of daminozide at various concentrations in other ornamental species.
- Results indicate a need for long term effects of growth retardants on ornamental plant species.
- Standardization of dosage of growth retardants for different crops is needed so that an appropriate growth and flowering can be achieved.

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# APPENDICES



**APPENDIX-I**

**WEEKLY METEOROLOGICAL DATA RECORDED AT ARI, RAJENDRANAGAR DURING 2015-16**

Date		Month	Temperature (0C)			R.H (%)		Sunshine (hrs)	Rainfall (mm)	Rainy days	Wind speed (Km/hr)	Evaporation (mm)
From	To		Max	Min	Mean	I	II					
30-07-15	05-8-15	August	32.80	23.0	27.9	80.1	47.7	6.3	8.0	2	8.7	6.9
06-08-15	12-8-15	August	31.40	23.8	27.6	87.1	66.0	3.9	10.8	2	6.2	5.0
13-08-15	19-08-15	August	30.45	22.4	26.42	89.7	69.0	3.7	30.0	4	3.7	3.5
20-08-15	26-08-15	August	31.5	22.7	27.1	90.6	64.6	6.6	49.4	2	3.3	5.4
27-08-15	02-09-15	September	30.14	22.1	26.12	83.3	66.67	3.9	28.6	2	3.6	5.2
03-09-15	09-09-15	September	33.42	22.9	28.16	88.4	59.1	7.2	30.8	3	1.4	5.6
10-09-15	16-09-15	September	28.45	21.9	25.17	95.9	85.7	1.7	92.0	4	0.8	2.5
17-09-15	23-09-15	September	30.41	22.2	26.30	89.6	61.0	4.4	43.4	2	1.2	3.5
24-09-15	30-09-15	September	31.9	22.3	27.1	89.4	57.6	7.2	2.0	0	0.2	4.3
01-10-15	07-10-15	October	31.4	21.1	26.25	96.0	55.0	5.8	34.6	2	0.2	3.4
08-10-15	14-10-15	October	33.4	19.6	26.5	88.4	37.4	7.9	0.0	0	0.1	4.5
15-10-15	21-10-15	October	32.8	19.1	25.95	91.7	42.0	8.4	0.0	0	0.6	4.5
22-10-15	28-10-15	October	32.4	18.1	25.25	89.3	43.6	8.9	0.0	0	1.8	4.7
29-10-15	04-11-15	November	31.3	20.7	26.00	91.7	50.9	7.3	0.0	1	1.3	3.6
05-11-15	11-11-15	November	31.3	17.4	24.35	90.6	73.6	7.3	18.3	0	2.3	4.4
12-11-15	18-11-15	November	30.0	15.8	22.9	85.1	52.9	6.7	0.0	0	2.4	4.0
19-11-15	25-11-15	November	29.4	19.1	24.25	83.0	53.9	6.6	0.0	0	1.4	3.9
26-11-15	02-12-15	December	30.4	17.8	24.1	87.4	47.0	7.7	0.8	0	0.6	3.8
03-12-15	09-12-15	December	29.4	14.4	21.9	91.7	36.7	7.0	0.0	0	0.4	3.5
10-12-15	16-12-15	December	32.2	17.0	24.6	90.0	37.0	7.6	1.4	0	0.7	3.9
17-12-15	23-12-15	December	32.4	15.7	24.05	92.9	35.3	8.9	0.0	0	0.9	4.2

Date		Month	Temperature (0C)			R.H (%)		Sunshine (hrs)	Rainfall (mm)	Rainy days	Wind speed (Km/hr)	Evaporation (mm)
From	To		Max	Min	Mean	I	II					
24-12-2015	31-12-2015	December	30	11.1	20.55	73.3	24.6	8.8	0.0	0	0.8	3.9
01-01-2016	07-01-2016	January	30.4	11.8	21.10	84.1	26.0	9.6	0.0	0	0.9	3.9
08-01-2016	14-01-2016	January	29.2	11.0	20.10	78.4	25.6	9.1	0.0	0	1.2	3.9
15-01-2016	21-01-2016	January	29.1	16.6	22.85	76.6	34.6	6.8	0.0	0	1.6	3.7
22-01-2016	28-01-2016	January	29.1	15.6	22.35	79.4	37.3	7.2	0.0	0	1.6	3.8
29-01-2016	04-02-2016	February	32.9	13.6	23.25	70.7	25.6	9.7	0.0	0	1.2	4.6