

**EFFECT OF GROWTH RETARDANTS ON GROWTH
AND FLOWERING OF CHRYSANTHEMUM**
(Chrysanthemum morifolium Ramat.)

Thesis

**Submitted to the Punjab Agricultural University
in partial fulfillment of the requirements
for the degree of**

**MASTER OF SCIENCE
in
FLORICULTURE AND LANDSCAPING**
(Minor Subject: Botany)

By

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CERTIFICATE – I

This is to certify that the thesis entitled, “**Effect of growth retardants on growth and flowering of chrysanthemum (*Chrysanthemum morifolium* Ramat.)**” submitted for the degree of **M.Sc.** in the subject of **Floriculture and Landscaping** (Minor subject: **Botany**) of the Punjab Agricultural University, Ludhiana, is a bonafide research work carried out by **Navdeep Singh (L-2014-A-66-M)** under my supervision and that no part of this thesis/dissertation has been submitted for any other degree.

The assistance and help received during the course of investigation have been fully acknowledged.

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CERTIFICATE II

This is to certify that the thesis entitled, “**Effect of growth retardants on growth and flowering of chrysanthemum (*Chrysanthemum morifolium* Ramat.)**” submitted by **Navdeep Singh (L-2014-A-66-M)** to the Punjab Agricultural University, Ludhiana, in partial fulfillment of the requirement for the degree of **Master of Science**, in the subject of **Floriculture and Landscaping** (Minor subject: **Botany**) has been approved by the Student’s Advisory Committee after an oral examination on the same.

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ABSTRACT

The research entitled “Effect of growth retardants on growth and flowering of Chrysanthemum (*Chrysanthemum morifolium* Ramat.)” was conducted at Research Farm, Department of Floriculture and Landscaping, Punjab Agricultural University, Ludhiana, during the year 2015-16 to standardize the optimum concentration of different growth retardants for alteration of plant architecture and improvement of flowering parameters in chrysanthemum cvs. Anmol and Royal Purple. The rooted cuttings of both the varieties were transplanted in the 1st week of August with 11 treatments along with the control. The experiment was conducted in Factorial completely randomized design (FCRD) with three replications comprising ten pots per replication. Cycocel @ (500, 750, 1000, 1250 and 1500 ppm), Daminozide @ (500, 750 and 1000 ppm) and Ethephon @ (250, 500 and 1000 ppm) were sprayed on chrysanthemum cvs. Anmol (spray type) and Royal Purple after one month of transplanting. Plant height decreases in both the cultivars with increasing concentration of growth retardants. Plant height at first bud appearance (24.13 cm), (22.29 cm) and Internodal length (3.20 cm), (3.48 cm) was much reduced by daminozide @ 1000 ppm in both the cvs. Anmol and Royal Purple respectively. Highest plant spread (15.36 cm), (18.40 cm), diameter of main stem (5.90 mm), (5.97 mm) and leaf area (2.66), (1.93) was obtained under daminozide @ 1000 ppm in both the cvs. Anmol and Royal Purple respectively. Floral characters like days to bud appearance (80.56 days), (83.76 days), colour break stage (103.66 days), (105.76 days) and full bloom stage (123.56 days), (125.26 days) was obtained earlier in daminozide @ 1000 ppm and later in ethephon @ 1000 ppm in both the cvs. Anmol and Royal Purple respectively. Flower diameter (5.69 cm) and (5.86 cm) was much increased by daminozide @ 500 ppm in both the cvs. Anmol and Royal Purple respectively. Highest number of flowers/plant (31.06) and (26.56) was obtained under daminozide @ 1000 ppm in both the cvs. Anmol and Royal Purple respectively. Maximum duration of flowering (25.06 days) and (20.20 days) was also obtained under daminozide @ 1000 ppm and minimum under ethephon @ 1000 ppm in both the cvs. Anmol and Royal Purple respectively. Thus, from the present studies, it can be concluded that daminozide @ 1000 ppm concentration is the effective concentration in chrysanthemum.

Keywords: Chrysanthemum, Anmol, Royal Purple, Growth Retardants, vegetative and flowering characters

Signature of Major Advisor

Signature of the Student

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ਮੌਜੂਦਾ ਅਧਿਐਨ “ਗੁਲਦਾਉਦੀ (ਕ੍ਰਾਈਸੈਂਥੀਮਮ ਮੋਰੀਫੋਲੀਅਮ ਰੈਮਟ.) ਦੇ ਵਿਕਾਸ ਫੁੱਲ ਖਿੜਣ ਉਪਰ ਵਿਕਾਸ ਨੂੰ ਵਧਾਉਣ ਵਾਲੇ ਕਾਰਕਾਂ ਦੇ ਪ੍ਰਭਾਵ ਦਾ ਮੁਲਾਂਕਣ” ਸਿਰਲੇਖ ਅਧੀਨ ਪੰਜਾਬ ਖੇਤੀਬਾੜੀ ਯੂਨੀਵਰਸਿਟੀ, ਲੁਧਿਆਣਾ ਦੇ ਫਲੋਰੀਕਲਚਰ ਅਤੇ ਲੈਂਡਸਕੇਪਿੰਗ ਵਿਭਾਗ ਦੇ ਖੋਜ ਫਾਰਮ ਵਿਖੇ ਸੰਨ 2015-16 ਦੌਰਾਨ ਗੁਲਦਾਉਦੀ ਦੀ ਕਿਸਮ ਅਨਮੋਲ ਅਤੇ ਰਾਇਲ ਪਰਪਲ ਵਿੱਚ ਪੌਦੇ ਦੀ ਬਣਤਰ ਵਿੱਚ ਤਬਦੀਲੀ ਕਰਨ ਅਤੇ ਫੁੱਲ ਦੇ ਮਾਪਦੰਡਾਂ ਵਿੱਚ ਸੁਧਾਰ ਲਿਆਉਣ ਲਈ, ਵਿਕਾਸ ਨੂੰ ਵਧਾਉਣ ਵਾਲੇ ਵੱਖੋ-ਵੱਖਰੇ ਕਾਰਕਾਂ ਦੀਆਂ ਅਨੁਕੂਲਤਾ ਘਣਤਾਵਾਂ ਦੇ ਮਿਆਰੀਕਰਨ ਕਰਨ ਦੇ ਮਕਸਦ ਨਾਲ ਕੀਤਾ ਗਿਆ। ਦੋਨਾਂ ਕਿਸਮਾਂ ਦੀਆਂ ਕਲਮਾਂ ਨੂੰ ਅਗਸਤ ਦੇ ਪਹਿਲੇ ਹਫਤੇ ਕੰਟਰੋਲ ਅਤੇ 11 ਉਪਚਾਰਾਂ ਨਾਲ ਬੀਜਿਆ ਗਿਆ। ਤਜਰਬਾ, ਫੈਕਟੋਰੀਅਲ ਕੰਪਲੀਟਲੀ ਰੈਂਡਮਾਈਜ਼ਡ ਡੀਜ਼ਾਈਨ (FCRD) ਵਿਧੀ ਤਹਿਤ 10 ਪਲਾਟਾਂ ਵਿੱਚ ਤਿੰਨ ਵਾਰ ਦੁਹਰਾਇਆ ਗਿਆ। ਬੀਜਾਈ ਤੋਂ ਇੱਕ ਮਹੀਨੇ ਮਗਰੋਂ ਗੁਲਦਾਉਦੀ ਦੀਆਂ ਕਿਸਮਾਂ ਅਨਮੋਲ ਅਤੇ ਰਾਇਲ ਪਰਪਲ ਉਪਰ ਸਾਈਕੋਸੈਲ @ (500, 750, 1000, 1250 ਅਤੇ 1500 ਪੀ ਪੀ ਐਮ), ਡੈਮੀਨੋਜ਼ਾਈਡ @ (500, 750 ਅਤੇ 1000 ਪੀ ਪੀ ਐਮ) ਅਤੇ ਐਥੀਫੋਨ @ (250, 500 ਅਤੇ 100 ਪੀ ਪੀ ਐਮ) ਦਾ ਛਿੜਕਾਅ ਕੀਤਾ ਗਿਆ। ਵਿਕਾਸ ਨੂੰ ਤੇਜ਼ ਕਰਨ ਵਾਲੇ ਕਾਰਕਾਂ ਦੀ ਘਣਤਾ ਵਧਾਉਣ ਨਾਲ ਦੋਨਾਂ ਕਿਸਮਾਂ ਵਿੱਚ ਪੌਦੇ ਦੀ ਉਚਾਈ ਵਿੱਚ ਕਮੀ ਦਰਜ ਕੀਤੀ ਗਈ। ਅਨਮੋਲ ਅਤੇ ਰਾਇਲ ਪਰਪਲ ਦੋਨਾਂ ਕਿਸਮਾਂ ਵਿੱਚ ਡੈਮੀਨੋਜ਼ਾਈਡ @ 1000 ਪੀ ਪੀ ਐਮ ਦੇ ਛਿੜਕਾਅ ਨਾਲ ਪਹਿਲੀ ਕਲੀ ਦੇ ਨਿਕਲਣ ਸਮੇਂ ਪੌਦੇ ਦੀ ਉਚਾਈ (24.13 ਸੈ.ਮੀ., 22.29 ਸੈ.ਮੀ ਅਤੇ ਦੋ ਅੱਖਾਂ (ਗੰਢਾਂ) ਵਿੱਚਲੀ ਲੰਬਾਈ (3.20 ਸੈ.ਮੀ., 3.48 ਸੈ.ਮੀ.) ਵਿੱਚ ਕਮੀ ਆਈ। ਡੈਮੀਨੋਜ਼ਾਈਡ @ 1000 ਪੀ ਪੀ ਐਮ ਦੇ ਛਿੜਕਾਅ ਨਾਲ ਅਨਮੋਲ ਅਤੇ ਰਾਇਲ ਪਰਪਲ ਦੋਨਾਂ ਕਿਸਮਾਂ ਵਿੱਚ ਪੌਦੇ ਦਾ ਫੈਲਾਅ (15.36 ਸੈ.ਮੀ.), (18.40 ਸੈ.ਮੀ.), ਮੁੱਖ ਟਹਿਣੀ ਦਾ ਵਿਆਸ (5.90 ਮਿ.ਮੀ.), (5.97 ਮਿ.ਮੀ.) ਅਤੇ ਪੱਤੇ ਦਾ ਖੇਤਰਫਲ (2.66), (1.93) ਸਭ ਤੋਂ ਵਧੇਰੇ ਦਰਜ ਕੀਤਾ ਗਿਆ। ਅਨਮੋਲ ਅਤੇ ਰਾਇਲ ਪਰਪਲ ਦੋਨਾਂ ਕਿਸਮਾਂ ਵਿੱਚ ਫੁੱਲ ਦੇ ਗੁਣ ਜਿਵੇਂ ਕਿ ਕਲੀ ਦੇ ਖਿੜਨ ਲਈ ਲੱਗਣ ਵਾਲੇ ਦਿਨਾਂ ਦੀ ਗਿਣਤੀ (80.56 ਦਿਨ), (83.76 ਦਿਨ), ਰੰਗ ਬਦਲਣ ਦਾ ਪੜਾਅ (103.66 ਦਿਨ), (105.76 ਦਿਨ) ਅਤੇ ਪੂਰੇ ਜੋਬਨ ਤੇ ਫੁੱਲਾਂ ਦੇ ਖਿੜਨ ਦਾ ਸਮਾਂ (123.56 ਦਿਨ), (125.26 ਦਿਨ), ਪਹਿਲਾਂ ਡੈਮੀਨੋਜ਼ਾਈਡ @ 1000 ਪੀ ਪੀ ਐਮ ਦੇ ਉਪਚਾਰ ਵਾਲੇ ਪੌਦਿਆਂ ਵਿੱਚ ਅਤੇ ਇਸ ਉਪਰੰਤ ਐਥੀਫੋਨ @ 1000 ਪੀ ਪੀ ਐਮ ਦੇ ਛਿੜਕਾਅ ਵਾਲੇ ਪੌਦਿਆਂ ਵਿੱਚ ਵੇਖੇ ਗਏ। ਅਨਮੋਲ ਅਤੇ ਰਾਇਲ ਪਰਪਲ ਦੋਨਾਂ ਕਿਸਮਾਂ ਵਿੱਚ ਡੈਮੀਨੋਜ਼ਾਈਡ @ 500 ਪੀ ਪੀ ਐਮ ਦੇ ਛਿੜਕਾਅ ਨਾਲ ਫੁੱਲ ਦੇ ਵਿਆਸ ਵਿੱਚ ਬਹੁਤ ਵਧੇਰੇ ਵਾਧਾ ਹੋਇਆ ਜੋਕਿ ਕ੍ਰਮਵਾਰ 5.69 ਸੈ.ਮੀ. ਅਤੇ 5.86 ਸੈ.ਮੀ. ਦਰਜ ਕੀਤਾ ਗਿਆ। ਅਨਮੋਲ ਅਤੇ ਰਾਇਲ ਪਰਪਲ ਦੋਨਾਂ ਕਿਸਮਾਂ ਵਿੱਚ ਡੈਮੀਨੋਜ਼ਾਈਡ @ 1000 ਪੀ ਪੀ ਐਮ ਦੇ ਛਿੜਕਾਅ ਨਾਲ ਪ੍ਰਤੀ ਪੌਦਾ ਫੁੱਲਾਂ ਦੀ ਗਿਣਤੀ ਸਭ ਤੋਂ ਵਧੇਰੇ ਕ੍ਰਮਵਾਰ 30.06 ਅਤੇ 26.56 ਦਰਜ ਕੀਤਾ ਗਿਆ। ਅਨਮੋਲ ਅਤੇ ਰਾਇਲ ਪਰਪਲ ਦੋਨਾਂ ਕਿਸਮਾਂ ਵਿੱਚ ਡੈਮੀਨੋਜ਼ਾਈਡ @ 1000 ਪੀ ਪੀ ਐਮ ਦੇ ਛਿੜਕਾਅ ਨਾਲ ਉਪਚਾਰਤ ਪੌਦਿਆਂ ਵਿੱਚ ਫੁੱਲਾਂ ਦੇ ਖਿੜੇ ਰਹਿਣ ਦਾ ਅੰਤਰਾਲ ਸਭ ਤੋਂ ਵਧੇਰੇ (ਕ੍ਰਮਵਾਰ 25.06 ਅਤੇ 2.20 ਦਿਨ) ਅਤੇ ਐਥੀਫੋਨ @ 1000 ਪੀ ਪੀ ਐਮ ਦੇ ਛਿੜਕਾਅ ਵਾਲੇ ਪੌਦਿਆਂ ਵਿੱਚ ਨਾਲ ਸਭ ਤੋਂ ਸੀ। ਇਸ ਲਈ ਮੌਜੂਦਾ ਅਧਿਐਨ ਦੇ ਨਤੀਜਿਆਂ ਦੇ ਅਧਾਰ ਤੇ ਇਹ ਕਿਹਾ ਜਾ ਸਕਦਾ ਹੈ ਕਿ ਡੈਮੀਨੋਜ਼ਾਈਡ ਦੀ 1000 ਪੀ ਪੀ ਐਮ ਘਣਤਾ ਗੁਲਦਾਉਦੀ ਲਈ ਅਸਰਦਾਰ ਘਣਤਾ ਹੈ।

ਮੁੱਖ ਸ਼ਬਦ: ਗੁਲਦਾਉਦੀ, ਅਨਮੋਲ, ਰਾਇਲ ਪਰਪਲ, ਵਿਕਾਸ ਨੂੰ ਵਧਾਉਣ ਵਾਲੇ ਕਾਰਕ, ਬਨਸਪਤਕ ਅਤੇ ਫੁੱਲ ਦੇ ਗੁਣ

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CHAPTER I

INTRODUCTION

Chrysanthemum is one of the most beautiful and perhaps the oldest flowering plant, commercially grown in different parts of World (Dole and Wilkins 2005). It is a genus of approximately 30 species of perennial flowering plants belonging to family 'Asteraceae', found in Asia and north eastern Europe and commonly known as "Autumn Queen" or "Queen of East" (Bhattacharjee 2006). Chrysanthemum is classified as standard (Japanese- single flower) and spray (Korean- many flowers) types. There are more than 15,000 varieties available with different flower forms (incurved, pompon, anemone, reflex etc.), shape of petals (spider, spoon, tubular etc.) and colour (Larson 1992). Chrysanthemum ranks next to rose in the international flower market due to its vast range of shapes and sizes of flower, brilliant colour tones, long lasting floret life, variations among the cultivars with respect to growth habit of plant, flower shape, size and colour (Singh 2006). The Netherland and Columbia are the leading exporters of chrysanthemum and, in India; its cultivation is concentrated mainly in Karnataka, Tamil Nadu, West Bengal, Madhya Pradesh and Himachal Pradesh. In India, chrysanthemum cultivation covers 11.05 thousand hectare area with loose flower production of 106.76 million tonnes and cut flower production of 6.03 lakh flowers (Anonymous 2015). In the North-Indian plains, chrysanthemum has a year round demand as a flowering pot plant for decoration besides its use as a cut flower for making bouquets and as a loose flower for making garlands (Bohra and Kumar 2014). Chrysanthemum produces showy flowers with different flower colour, exceptionally hardy nature and relative ease to grow (Bhattacharjee 2006). Flower shape that can be used as pot plants for beautifying indoors and outdoors, as cut flowers for making bouquets and vase decoration, as loose flower for making garlands, worshipping purpose and for garden decoration. Therefore, it is the most important both as cut flower and as potted plant in international market.

During the last two decades, due to rapid urbanization, change in life style and consumer behaviour, there is tremendous increase of using ornamental pot plants (Kuehny *et al* 2001). They have been found to play significant role for beautification and indoorscaping in multiplexes due to scarcity of open space. In addition, strict specifications based on plant-to-pot ratio had forced the growers to standardize their production according to the prescribed standards laid by market retailers (Hall *et al* 2006). In chrysanthemum medium growth habit and freedom of profuse flower production, make it especially desirable for growing in pots/containers. These are also excellent bedding plants for winter and spring displays. But beauty and balance of the plant with the pot is marred by excessive long shoots, short lived and haphazard flowering. This has an adverse effect on its presentability.

In the North-Indian plains, the commercial growers propagate chrysanthemum plants through terminal stem cuttings at the end of June that can be extended up to the end of July. The growth and yield of plants is mainly influenced by two principal factors viz., genetical and management. 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. These substances modify the plant physiological processes within the plant, which ultimately affects plant growth and development (Dutt *et al* 2002).

Therefore, to achieve the desired shape, size and form of the plants use of growth retardants is a must. Growth retardants are now a day being tried for controlling growth and flowering of chrysanthemum with a view to have compact plants, to stretch-out or retard the rate of plant growth and also to hasten or delay the flowering period (Anderson 2006). Growth retardants are organic compounds, other than plant nutrients, which when used in minute quantities retard, stem elongation, increase green colour of leaves, affect flowering and fruiting without causing malformation of plants. These are either natural or synthetic. Natural retardants are ABA (Abscisic acid), BA (Benzoic acid), Ferulic acid and Jasmonic acid and synthetic are TIBA (Tri ido-benzoic acid), MA (Maleic Hydrazide), Morphactins, CCC (Cycocel), Phosphon D and Paclobutrazol. Suppression of growth by growth retardants occurs because the compound blocks three steps in the terpenoid pathway for the production of the hormone gibberellin by binding with and inhibiting the enzymes that catalyze the metabolic reactions (Cathey 1964). There are different factors that affect growth retardant performance like environmental conditions, production practices, cultivar differences, application techniques and timing.

Plant growth retardants can be an economical option for controlling growth, and often these chemicals also improve the quality and overall appearance of many plants including herbaceous perennials (Mcmahon and Kelly 1999). These are mainly used because of their retarding effect on shoot growth, breaking of apical dominance, which induce dwarf and bushy plants and increase the number of lateral branches in plants (Rademacher 2000). Pot chrysanthemums are usually treated with chemical growth retardants to ensure strong compact growth, by preventing them from growing to their full height, and in order to meet market specifications. The plant growth regulators modify physiological processes of the plants and ultimately affect yield and quality of blooms. Sharifuzzaman *et al* (2011) applied GA₃ @ (50, 100, 150 ppm), CCC @ (400, 600, 800 ppm) and MH @ (250, 500, 750 ppm) and observed that GA₃ treated plants showed significant increase in plant spread, leaf number and leaf length. Whereas, in CCC @ 800 and 600 ppm more number of suckers were produced.

Pobudkiewicz (2014) applied a single flurprimidol foliar spray 7.5, 15 or 22.5 mg/ dm³ in chrysanthemum cvs. “Kodiak” and “Jewel Time”, grown in pots and observed flurprimidol was effective in reducing stem extension without adverse side-effects. The effect of chlormequat @ (0, 500, 1000 and 1500 mg/L) and daminozide @ (0, 1500, 3000 and 4500 mg/L) on plant height and flowering of pot marigold (*Calendula officinalis*) was investigated by Kazemi *et al* (2014) and demonstrated that the minimum plant height was in treatment of 500 mg/L cycocel + 3000 mg/L daminozide and more number of flowers (4.66 flowers/plant) in treatment of 1000 mg/L cycocel + 4500 mg/L daminozide.

Retardants commonly applied as foliar spray or a substrate drench. It can be applied as a single high dose drench to provide season long control of growth. CCC (cycocel), daminozide and ethephon is applied only as foliar spray because it is rapidly broken down when applied to the substrate (Cathey 1975). It is highly mobile in the plant and will rapidly move from the point of application to all parts of the plant. The time of application can greatly influence the growth pattern of the crop thereby, modifying its presentability.

Therefore, keeping in view the potential of chrysanthemum as a pot plant, the present investigations were under taken with the following objectives:

- 1) To standardize the optimum concentration of different growth retardants in chrysanthemum for plant architecture.
- 2) To study the effect of different growth retardants on flowering parameters of chrysanthemum.

CHAPTER II

REVIEW OF LITERATURE

The proposed research work has been undertaken to study the effect of different growth retardants on growth and flowering of chrysanthemum under Punjab conditions. Besides, there was tremendous need to formulate optimum concentrations of growth retardants to control the height and for good quality flower production.

The relevant literature in support of the above research problem has been reviewed as below:

2.1 Effect of different growth retardants on plant architecture

2.2 Effect of different growth retardants on flowering parameters

2.1 Effect of different growth retardants on plant architecture

Kher (1974) investigated the effects of Ethrel on the growth and flower formation in pot chrysanthemums. Ethrel was sprayed at 2,000 ppm concentration on pinched and unpinched plants of pot chrysanthemum cultivar 'Jack Straw' in early vegetative stage. Results showed a reduced plant height, shortening of internode leading to rosette formation, increased number of new shoots and temporary damage and atrophy of leaves in Ethrel sprayed plants. When applied as soil drench at the above concentration, the responses were almost the same but poorer compared to spray application.

Menhett (1977) studied a new quaternary ammonium growth retardant, i-allyl-i-(3, 7-dimethyl-octyl)-piperidinium bromide (ADOPB), that was compared with daminozide, ancymidol and dikegulac-sodium for its effectiveness in reducing lateral stem length in the pot chrysanthemum (*Chrysanthemum morifolium*). Single foliar sprays of ADOPB applied at 100 to 250 ppm active ingredient (a.i.) gave excellent height control without phytotoxicity in cv. Bright Golden Anne throughout the year. Similar results were obtained in two trials with cvs. Purple Anne and Regal Anne. As much as 10 to 50 times this concentration of daminozide was required to achieve a similar degree of height control. However, under summer conditions even high concentrations of daminozide did not adequately reduce stem length. Foliar sprays of ancymidol (50–100 ppm a.i.) also gave good control of stem length but this chemical was more effective when applied as a compost drench. Compost drenches of ADOPB reduced stem extension but a greater quantity of a.i. was required compared to a foliar spray. Foliar sprays of dikegulac-sodium (100 to 5000 ppm a.i.) were very phytotoxic.

Sanderson and Martin (1978) studied various Stemtrol (piproctanyl bromide or 1-allyl-1-(3, 7-dimethyloctyl)-piperidinium bromide) treatments that were compared to 5,000 ppm B-9 (SADH or succinic acid- 2, 2-dimethylhydrazide) spray for height control in potted chrysanthemums. Stemtrol sprays (50 to 150 ppm) were applied to the chrysanthemum

cultivars 'Sunny Mandalay' and 'Orange Bowl'. Both sprays (50 to 250 ppm) and drenches (50 to 500 ppm, 120 ml per 6 x 4.75 inch (16 x 12 cm) pot) of Stemtrol were used on the cultivar 'Bright Golden Yellow Princess Anne'. Treatments were applied after pinching when new shoots were 1.0 inch (2.5 cm) long. On 'Orange Bowl' plants, a 150 ppm Stemtrol spray gave height control comparable to a 5,000 ppm B-9 spray. With 'Sunny Mandalay' plants, the 5,000 ppm B-9 spray produced the shortest plants. Stemtrol was effective both as a spray (100-150 ppm) and drench (200 ppm) on 'Bright Golden Yellow Princess Anne' plants.

Barrett *et al* (1986) examined the effect of different growth retardants on rooted cuttings of *Chrysanthemum morifolium* 'pert' and 'bright golden anne' planted five per 15 cm pot. Paclobutrazol was applied as a spray @ (100, 200 and 400 ppm) once or twice or as a drench @ (0.125, 0.25 and 0.5 mg/pot). XE-1019 (Sumagic) was applied as a one time spray @ (6.25, 12.5 and 25 ppm) or a drench @ (0.25, 0.05, and 0.1 mg/pot). Daminozide was applied as a spray @ 2500 ppm once to 'pert' and @ 5000 ppm twice to 'bright golden anne'. For 'bright golden anne' treatments resulting in plants similar to two daminozide sprays at 5000 ppm, paclobutrazol at 400 ppm once or 100-200 ppm twice as a spray or at 0.5 mg/pot as a drench and XE-1019 (Sumagic) as a 0.1 mg/pot drench. Spray of XE-1019 at 25 ppm produced plants 5 cm taller than the daminozide treatment. For 'pert', treatments resulting in plants similar to daminozide at 2500 ppm applied once were sprays of paclobutrazol at 200-400 ppm once or 500 ppm twice or a drench at 0.25 mg/pot and XE-1019 spray at 6.25-25 ppm or a drench at 0.025 mg/pot.

Zalewska (1989) reported that Alar (Daminozide) applied at a concentrations (1250, 2500, 5000 mg/l) on local cultivar of *Chrysanthemum morifolium* as foliar spray. He revealed that alar concentration 5000 mg/l on pot cultivated chrysanthemum had the biggest dwarfing effect on the internodal length which decreases approximately from 2 cm to 1.75 cm within time period of 1 to 7 weeks.

Starman (1990) compared Single and multiple sprays of uniconazole at 0, 5, 10, or 20 mg/l with daminozide sprays at 2500 mg/l applied twice for height control of chrysanthemum cultivars 'Puritan' and 'Favor'. A single uniconazole spray at 20 mg/l applied 2 weeks after pinching or two uniconazole applications at 10 mg/l applied 2 and 4 weeks after pinching were as effective as daminozide for reducing height. The height reduction in Puritan (40.2cm) and in Favor (42.2cm) with daminozide application was recorded.

Wilfret (1991) studied *Chrysanthemum (Dendranthemum X grandiflorum (Ramat.) Kitamura)* plants were grown in six inch containers in first and second year to compare the effect of uniconazole and daminozide on plant growth. Twenty and 37 cvs. were grown first and second year, respectively in a shade house (25% light exclusion). Single application of

uniconazole (0, 10 and 20 ppm) or two application of daminozide (2500 ppm) were made in first year while in second year two applications of uniconazole (0 and 10 ppm) were compared to three applications of daminozide (2500 ppm). Cultivar response was variable and cultivar X treatment interactions were highly significant in both years. Plant height decreased in first year as uniconazole concentration increased, and daminozide generally yielded plants of same height or shorter than plants treated with uniconazole at 20 ppm. Several cultivars, such as 'Chic', 'Fontana', 'Karma' and 'Raye' were shorter with single applications of uniconazole at 20 ppm. In first year, two sprays of uniconazole at (10 ppm) generally produced plants with height equivalent to that produced by three applications of daminozide (2500 ppm). Uniconazole was shown to be a viable alternative to daminozide for chrysanthemum height control and was effective at much lower concentrations than daminozide.

Schuch (1994) used Uniconazole and daminozide as dip on unrooted cuttings or as foliar spray on pinched (*Dendranthema grandiflora* Tzvelev.) 'Dalvina' to control height. Stem elongation was determined on cuttings dipped in solutions of 0, 1.25, 2.5, 5, or 10 mg/L uniconazole or cuttings were dipped and later treated with foliar sprays in concentrations of 1.25/5, 1.25/10, 2.5/10, and 5/5 mg/L uniconazole, respectively. Other plants were sprayed once or twice with uniconazole at 10 mg/L. Daminozide treatments included a pre plant dip/foliar spray application of 1000/2000 mg/L, respectively, or two foliar sprays of 2,000 mg/L. Uniconazole dip alone retarded stem elongation linearly up to 8 weeks after propagation, 5 weeks after pinching, but was not discernible from the control treatment 8 weeks after pinching. Uniconazole at 2.5/10 and 5/5 mg/L as a dip/spray combination resulted in plants 33% shorter than the control at the end of the production. Doubling uniconazole dip or spray treatments from 5 to 10 mg/L provided no additional reduction of stem elongation. The single uniconazole spray and both daminozide treatments had no effect on final height, although daminozide treatments reduced stem dry weight compared to the control. Stem dry weight was reduced by uniconazole dip/spray combinations compared to dip treatments alone. Similarly, inflorescence and root dry weights were also reduced by the highest uniconazole concentrations.

Sharma *et al* (1995) reported that the growth parameters of chrysanthemum varied significantly with different concentrations of Alar (0, 1500, 3000, 4500 mg/l) as foliar spray. The resulted plants were significantly shorter as compared to the control plants. All of these parameters tended to decrease as the rate of the spray increased. The maximum retardation was obtained with Alar at 4500 ppm (12.17cm) followed by 3000 ppm (14.33 cm) and maximum plant height was recorded with control (16.80 cm).

Saikia and Talukdar (1997) reported that treating chrysanthemum cv. Prof. Harris with B-9 (2500, 5000 and 1000 ppm) and MH (250, 500 and 1000 ppm) as foliar spray both in pinched and unpinched plants resulted in maximum height reduction with 1,000 ppm MH.

Gad *et al* (1997) reported significant reduction in plant height when Paclobutrazol was applied as soil drench (5.33 cm) or foliar spray (6.0 cm) on fuchsia cv. 'Beacon' and 'Bellarina'. It also decreased internodal length by 52.2 and 60.9 per cent as compared with control when applied as foliar spray at 0, 500 and 1000 ppm and soil drenches at 0, 1.0 and 2.0 mg a.i. per pot.

Singh *et al* (1999) applied paclobutrazol (0, 10, 20, 40 and 60 ppm) as root dip, soil drench and foliar spray with all possible combinations on chrysanthemum cvs. White stafour and Bronze Mandial. It was found that plant height reduction increased with increasing concentrations of paclobutrazol. Root dip method was the most effective method in plant height reduction. Flowering was delayed more with increasing concentration by root dip method. The flower longevity was increased by increase in concentration i.e 10, 20, and 40 ppm but 60 ppm concentration lowered flower longevity. The soil drench and foliar spray treated plants gave higher number of flowers in both the cultivars. With cv. White stafour, application of 10 and 20 ppm, while 20 and 40 ppm paclobutrazol in cv. Bronze Mandial significantly increased the number of flowers over control.

Meher *et al* (1999) applied MH (750, 1000, 1250 mg/l) as foliar spray and reported that with the application of Maleic Hydrazide (MH) @ 1250 mg/l, the maximum reduction in plant height (16.4 cm), more number of branches per plant (8.3) as well as greater spread of plants in terms of both N-S (34.0 cm) and E-W (35.6 cm) was recorded. The reduction in plant height may be due to the fact that MH causes complete suppression of apical dominance by inhibiting the cell division which in terms induces the lateral growth and ultimately also increases the number of branches and thereby plant spread.

Pateli *et al* (2004) studied the effect of paclobutrazol, triapenthenol, daminozide and chlormequat chloride on the growth of *Epidendrum radicans*. Paclobutrazol and triapenthenol were applied as soil drenches at 5, 10 and 20 mg/l, while 1000, 2000 and 4000 mg/l daminozide and 2000, 4000 and 6000 mg/l chlormequat chloride were applied as foliar sprays. Main and lateral shoot growth restriction (54-75%) was obtained by all doses of paclobutrazol and 20 and 10 mg/l triapenthenol. Daminozide at 4000 and 2000 mg/l restricted only main shoot growth. Chlormequat chloride at 6000 mg/l had a similar effect but caused leaf toxicity symptoms, as white spots. The effect of the four growth retardants on shoot growth restriction followed the order paclobutrazol>triapenthenol>daminozide>chlormequat chloride. Leaf length was much reduced (46-62%) by all doses of paclobutrazol and the two

higher doses of triapenthenol and to a lesser extent (13-29%) by all doses of daminozide and the lower dose of triapenthenol, while it was not affected by chlormequat chloride. Leaf width was restricted (13-37%) by the two higher doses of paclobutrazol, triapenthenol and daminozide and the highest dose of chlormequat chloride. Leaf thickness was much increased (52-76%) by all doses of paclobutrazol and the two higher doses of triapenthenol. The lower dose of triapenthenol and daminozide, and all doses of chlormequat chloride, caused a smaller increase in leaf thickness (17-37%).

Karlovic *et al* (2004) observed that the influence of different concentrations of growth retardants, daminozide (1000, 2000 and 3000 mg/l) and chlormequat (2000, 3000 and 4000 mg/l) on plant height and number of shoots of the chrysanthemum cultivar 'Revert' by foliar application. Two height measurements were taken in the first year, just before the growth retardant application and 14 days after it. In the second trial year, plant height was measured four times, before the growth retardant application and at 14, 30 and 42 days after the treatment. The lowest plant height was obtained by treating plants with daminozide @ 2000 and 3000 mg/l and chlormequat @ 3000 and 4000 mg/l as compared to the control.

Moond *et al* (2006) studied the effect of GA₃ @ (50, 100, 150, 200 and 250 ppm), CCC @ (2000, 4000, 6000, 8000 and 10,000 ppm) and MH @ (250, 500, 750, 1000 and 1250 ppm) on growth and flowering of chrysanthemum. Minimum plant height (104 cm) was recorded with MH at 1250 ppm, while shortest internode (1.64 cm) and maximum number of internodes (52.6) were produced with 10,000 ppm CCC. GA₃ at 250 ppm resulted in tallest plants (178 cm) with longest internodes (3.83 cm). MH at 1250 ppm produced maximum number of primary branches (38.8) and leaves per plant (1878), whereas, CCC at 4000 ppm recorded plants with maximum basal diameter of stem (3.15 cm).

Haque *et al* (2007) conducted an experiment to study the effect of ethrel, chlormequat chloride and paclobutrazol on growth and pyrethrins accumulation in (*Chrysanthemum cinerariaefolium*) and they determined after application of ethrel at 50, 100, 250 and 500 mg/l produced a significant positive effect on pyrethrins level, decreased plant height, while 50 and 100 mg/l significantly increased fresh and dry flower yield. Chlormequat chloride at 1000 and 2000 mg/l and paclobutrazol at 80 and 160 mg/l increased pyrethrins level, single flower weight and decreased plant height and flower yield.

El-Sheibany *et al* (2007) observed that a local cultivar of *Chrysanthemum morifolium* was treated with growth retardant Alar as a foliar spray at different rates (1250, 2500, 5000 mg/l). The results revealed that treated plants, compared to untreated, were significantly shorter in stem length (7cm) and internodes length (1.87cm) when treated with Alar at concentration 5000 mg/l.

El-Sheibany *et al* (2008) observed that the growth retardant Alar was applied at different rates (1250, 2500, 5000 mg/l) as foliar spray to study its effects on some anatomical and chemical changes (number of palisade cells) in stems cutting growth of local cultivar of *Chrysanthemum morifolium* in terms of leaf area, leaf thickness and chlorophyll content. The results showed that treated leaves were normal in shape but with reduction in the leaves area associated with darker green colour.

Zhou (2008) studied the effects of B9 and CCC @ (500, 800, 1000, 1200 and 1500 mg/L) on the growth, flowering and physiological characteristics of (*Chrysanthemum morifolium*). He found the plant height, branch number and the leaf number of *Chrysanthemum morifolium* were significantly decreased, and the dwarfing effect was greater when B9 was higher than 1000 mg/L or CCC was higher than 1200 mg/L. B9 and CCC all could delay the flowering date to different degree. After B9 and CCC were sprayed on *C.morifolium*, the content of chlorophyll and soluble sugar in leaves was significantly increased, the leaf color became deeper, and the photosynthetic efficiency was increased. So 1000 mg/L of B9 and 1200 mg/L of CCC had better comprehensive effects on improving plant type of *C.morifolium* and increasing its ornamental value and physiological quality.

Navale *et al* (2010) conducted an experiment to study the effect of plant growth regulators on growth, flowering and yield of chrysanthemum cv. 'IIHR-6'. The results revealed that plant sprayed with MH at 1250 mg/l recorded the maximum reduction in plant height (16.4 cm) with maximum number of branches (8.2 cm) and plant spread in terms of both N-S (34.0 cm) and E-W (35.6 cm).

North *et al* (2010) tested Pink dombeya (*Dombeya burgesiae*) for its potential as a flowering potted plant, using the growth retardant Cycocel (2-chloroethyl)-trimethyl ammonium chloride. The treatments included a control, 0.5, 1, 2 and 3 mg/L of Cycocel per pot and were applied when seedlings reached 7 - 8 cm in height. All treatments significantly reduced plant height. The plants treated with 0.5 mg/L were only marginally shorter than the control, while the height of plants treated with 1, 2 and 3 mg/L Cycocel, were greatly reduced. Increased Cycocel concentrations decreased plant width in all treatments, as compared with the control.

Kazaz (2010) studied the effect of foliar treatments of gibberellic acid (GA₃) and paclobutrazol (PBZ) on the growth and flowering characteristics of goldenrod (*Solidago x hybrida* cv. 'Tara') grown under open field conditions. Beginning from 30 days after planting, GA₃ @ 250 mg/L was sprayed on plants 0 times (control), once and twice at one-week intervals, and again 30 days after planting, PBZ @ 125, 250 and 500 mg/L was sprayed on plants once. The stem length was 68.51 cm in the control, while it was 78.61 cm and 83.33

cm in the plants treated once and twice with GA₃, respectively and 60.17 cm, 55.38 cm and 50.71 cm in the plants treated with 125, 250 and 500 mg/L of PBZ, respectively. The number of secondary inflorescences per stem was 29.70 and 31.43 in the plants treated once and twice with GA₃, respectively and 21.96 in the control, whereas it ranged from 20.07 to 20.67 in the PBZ treatments. The number of stems per plant was 0.94 in the control, 1.45 and 1.62 in the plants treated once and twice with GA₃, respectively and ranged from 0.83 to 0.91 in the PBZ treatments. With respect to almost all characteristics, the best results were recorded in plants treated once and twice with GA₃.

Kim *et al* (2010) investigated the effect of Prohexadione Calcium (Pro-Ca) and daminozide on the growth characteristics and endogenous gibberellin contents of *Chrysanthemum morifolium* R. cv Monalisa White. Three concentrations viz. 100, 200 and 400 ppm of Pro-Ca and a single concentration of daminozide (800 ppm) were applied three times with 7 days interval on three weeks old plant under greenhouse condition. Pro-Ca suppressed the plant length up to 30.7% while daminozide inhibited up to 27.12% at optimum concentration. The chlorophyll contents and stem diameter were higher than control, while the fresh weight and flower number insignificantly reduced with such treatments. Gibberellin (GA) analysis showed that Pro-Ca and daminozide application significantly lowered bioactive GA₁ content, although the amount of its immediate precursor GA₂₀ was fractionally higher. Bioactive GA₄ content was slightly higher than the control while significant difference in GA₉ was found between the plants treated with Pro-Ca and daminozide.

Jamal Uddin *et al* (2011) reported that on foliar application of growth chemicals (F0; control, F1; Wuxol; F2; Vegimax, F3; Agro grow and F4; Surgrow) with 3 replications, the tallest plant (38.2 cm), maximum number of leaves (31.6) were recorded from vegimax while the shortest plant (31.4cm) and minimum number of leaves (21.3) were recorded from control.

Sharifuzzaman *et al* (2011) observed the effect of different concentrations of Gibberellic acid (GA₃), Cycocel (CCC) and Maleic Hydrazide (MH) on the vegetative growth, yield and quality of chrysanthemum cv. CM-019. Four weeks old seedlings were transplanted in pots and aqueous solution containing 3 concentrations of GA₃ (50, 100, 150 ppm), CCC (400, 600, 800 ppm) and MH (250, 500, 750 ppm) were applied along with (control). GA₃ treated plants showed significant increase in plant spread, leaf number and leaf length. Higher number of suckers (20) per plant was produced when pots were treated with GA₃ @ 150 ppm followed by GA₃ @ 100 ppm (18), whereas, in CCC @ 800 and 600 ppm, 5 and 7 suckers were produced respectively.

Hashemabadi *et al* (2012) studied the effect of spray application of two plant growth retardants (cycocel and daminozide) on the growth of *Calendula officinalis* L. Combinations of cycocel (CCC) (0, 500, 1000 and 1500 mg/L) and daminozide (B9) (0, 1500, 3000, and 4500 mg/L) was used three times. Plant height and the number of leaves per plant was measured. Results showed that the effect of CCC and B9 were significant on plant height ($p \leq 0.01$). Also, interaction effects of CCC and B9 were significant on plant height and number of leaves per plant. The lowest plant height (30.67 cm) and the highest number of leaves (6.67) were observed in 500 mg/L CCC + 4500 mg/L B9 and 500 mg/L CCC + 1500 mg/L B9, respectively.

Kazemi *et al* (2014) observed the effect of of chlormequat @ (0, 500, 1000 and 1500 mg/L) and daminozide @ (0, 1500, 3000 and 4500 mg/L) on plant height, flowering, the content of essence and some other traits in pot marigold (*Calendula officinalis*). Investigated characteristics were plant height, leaf number, flower number, flowering time, fresh weight, dry matter, the content of essence and carotenoid in flowers. The minimum height (24 cm/plant) in treatment of 500 mg/L cycocel + 3000 mg/L daminozide, the largest number of flowers (4.66 flowers/plant) in treatment of 1000 mg/L cycocel + 4500 mg/L daminozide and most essence content (0.154 mg/100 g) in treatment of 4500 mg/L daminozide without cycocel were obtained.

Pobudkiewicz (2014) evaluated the effectiveness of a single flurprimidol foliar spray on growth, flowering, transpiration rate and stomatal conductance of medium height chrysanthemums “Kodiak” and “Jewel Time”, grown in pots. Flurprimidol applied once, as a foliar spray, at concentrations of 7.5, 15 or 22.5 mg/ dm³ was effective in reducing stem extension without adverse side-effects. The degree of growth inhibition varied by cultivar and flurprimidol concentration. The desirable heights of “Jewel Time” and “Kodiak” chrysanthemums were obtained with flurprimidol at 7.5 or 22.5 mg/ dm³ respectively. Growth retardant slightly delayed anthesis, reduced the canopy width, the leaf area, plant dry weight and the number of inflorescences but had no effect on inflorescence diameter. There was no significant effect of flurprimidol on leaf stomatal conductance to water vapor and transpiration rate per unit leaf area of both chrysanthemum cultivars.

2.2 Effect of different growth retardants on flowering parameters

Sharma *et al* (1990) carried out an experiment on 4-year-old damask rose plants. Plants were sprayed with CEPA (ethephon) (0.02, 0.04, 0.06, 0.08 or 0.10%) at 3 growth stages (vegetative, floral bud formation and flowering). Tween-20 (0.01%) was used as a wetting agent. The highest flower yield (2.073 kg), number of branches/plant (47.6) and oil yield (0.383 g/plant) were obtained with application of 0.06% CEPA.

Moond *et al* (2006) studied the effect of GA₃ @ (50, 100, 150, 200 and 250 ppm), CCC @ (2000, 4000, 6000, 8000 and 10,000 ppm) and MH @ (250, 500, 750, 1000 and 1250 ppm) on growth and flowering of chrysanthemum. Maximum flower yield per plant (815 g) was recorded with GA₃ at 150 ppm, whereas, MH at 1250 ppm produced highest number of flowers (371) per plant.

Kahar (2008) investigated the effects of frequency and concentration of B-9 application on growth, flowering and flower quality of 'Reagan Sunny' chrysanthemum. The frequencies tested were one, two and three applications, and the concentrations were 0, 1,250, 2,500, 3,750 and 5,000 mg/L. The time of flowering was delayed with the increased in B-9, however there was improvement in flowering synchrony. There was a strong interaction effect of frequency and concentration on vase life, where increased the concentration from 0 to 5,000 mg/ L, double the vase 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 is recommended for production of good spray form and long vase life for chrysanthemum in the lowlands.

Kazaz *et al* (2010) evaluated the effects of different day lengths and daminozide on days to flower, some quality parameters and chlorophyll contents of spray chrysanthemum plants (*Chrysanthemum morifolium* cvs. 'Yellow Reagan' and 'White Reagan') grown under greenhouse conditions. Day length and daminozide @ (3000 mg/L) significantly affected days to flower, stem length, stem diameter and flower numbers per stem. While stem fresh weight and chlorophyll *a* and *b* contents were affected by day length, daminozide had an insignificant effect on these parameters. Long day (LD) conditions delayed days to flower by 42 days as compared to short day (SD) conditions. SD conditions reduced stem length (84.47 cm) by almost 2-fold as compared to LD conditions (169.88 cm). Under SD conditions, the stem lengths of plants treated (3000 mg L⁻¹) and untreated (control) with daminozide were 79.21 and 89.73 cm, respectively, whereas under LD conditions, they were 156.33 and 183.43 cm, respectively. The flower number increased per stem both under SD conditions and with daminozide application. The numbers of flowers per stem were 13.40 and 11.87 under SD and LD conditions, respectively, and 14.11 flowers were obtained from the plants treated with daminozide, while 11.17 flowers per stem were obtained from the plants untreated with daminozide. LD conditions increased both chlorophyll *a* (11.50 µg/mg) and chlorophyll *b* (5.93 µg/mg) contents as compared to SD conditions.

Navale *et al* (2010) conducted an experiment to study the effect of plant growth regulators on growth, flowering and yield of chrysanthemum cv. 'IIHR-6'. The results revealed that plant sprayed with MH at 1250 mg/l recorded the maximum shelf life (14.2

days) and vase life of flowers (16.5 days). However, in case of flower yield per plant (33.3) and per hectare (21.7 t/ha), the lower concentration of MH at 750 mg/l was found significantly superior as compared to other treatment.

Singh (2010) investigated the effect of paclobutrazol (0, 10 and 20 ppm) on growth, flowering and pot presentability of florist's geranium grown in seven different potting mixtures in earthen pots (20 cm diameter). He reported better growth and flowering when paclobutrazol was applied @20 ppm as drenching. However, maximum pot presentability score (79.00) was recorded with paclobutrazol when drenched @10 ppm.

Jamal Uddin *et al* (2011) reported that on foliar application of growth chemicals (F0; control, F1; Wuxol; F2; Vegimax, F3; Agro grow and F4; Surgrow) with 3 replications, maximum number of flowers (58.6) per plant were recorded from vegimax and minimum number of flowers per plant (32.1) were recorded from control. Application of surgrow increased the petal brightness but vegimax was found suitable for growth, coloration and yield of chrysanthemum.

Hashemabadi *et al* (2012) studied the effect of spray application of two plant growth retardants (cycocel and daminozide) on the growth, flowering and amount of essential oils of *Calendula officinalis* L. Combinations of cycocel (CCC) (0, 500, 1000 and 1500 mg/L) and daminozide (B9) (0, 1500, 3000, and 4500 mg/L) was used three times. Number of flowers per plant, flower dry weight, flower fresh weight, time of flowering and the amount of essential oils per 100 g dried flower were measured. Results showed that the effect of CCC and B9 were significant on the amount of essential oils per 100 g dried flower. Also, interaction effects of CCC and B9 were significant on the number of flowers per plant, flower dry weight and the amount of essential oils per 100 g dried flower. The maximum number of flowers per plant (3.33) and the highest amount of essential oils per 100 g dried flower (0.159 ml) were observed in 500mg/L CCC + 1500 mg/L B-9 and 1500 mg/L CCC + 1500 mg/L B9, respectively.

Patil *et al* (2013) investigated the effect of three growth retardants i.e. MH @ (500, 1000, 1500 ppm), Alar @ (500, 1000, 1500 ppm) and cycocel @ (500, 1000, 1500 ppm) on yield and vase life of china aster (*Callisthus chinensis* L. nees). Results revealed that, significantly maximum number of branches per plant (24.20) was noticed in application of 1500 ppm cycocel to Phule Ganesh Violet followed by application of 1000 ppm cycocel (22.70). Whereas minimum number of branches per plant recorded in untreated (control) plants (14.00). It was observed that number of flowers per hectare differed significantly due to growth retardants. Spraying cycocel 1500 ppm with Phule Ganesh Violet produced significantly the highest number of flowers per hectare (65.07 lakh) followed by Phule

Ganesh White with cycocel 1500 ppm (61.74 lakh). Significantly the lowest number of flowers per hectare was recorded in untreated (control) plants of Phule Ganesh White and Phule Ganesh Violet (42.13 lakh and 47.28 lakh respectively).

Asrar *et al* (2014) studied the effect of growth retardant Alar and slow-release fertilizer Osmocote applications on growth and flowering quality and some chemical constituents of chrysanthemum (*Dendranthema grandiflora*) cvs. (Kodiak 'yellow', Ivyridgf 'white', Auburn 'red' and Lansing 'pink'). Alar at 0, 1500, 3000 and 4500 ppm as a foliar spray and Osmocote were incorporated in potting substrate at 0, 70, 140 and 280 mg/kg soil. Among different treatments, 1500 ppm gave reduction in flowering and early flowering. The remarkable increase in growth and flowering parameters were found with Osmocote treatment at 70 mg/ kg soil. Therefore, we proved that all cultivars treated with 1500 ppm Alar were compact and had large flower diameters, and the best vegetative growth and flower quality was found with application of the slow-release fertilizer Osmocote at 70 mg/ kg.

Naidu *et al* (2014) investigated the effective growth retardant concentrations for vegetative growth and flower yield of African marigold cv. Pusa Narangi Gaiinda. Plants were sprayed with CCC, TIBA, and MH @ 750, 1000 and 1250 ppm respectively at a spacings of 30 x 20 cm and 40 x 20 cm. MH @ 1250 ppm enhanced number of flowers and TIBA @ 1000 ppm recorded maximum flower diameter. CCC @ 750 ppm recorded maximum flower yield per plant and hectare. Among spacings 30 x 20 cm enhanced number of flowers, flower weight, flower size and yield per plant. Spacing of 40 x 20 cm enhanced the flower size, fresh flower weight, number of flowers and flower yield. CCC at 750 ppm with 30 x 20 cm spacing recorded maximum flower yield of 26.23 tonne/hectare.

CHAPTER III

MATERIAL AND METHODS

The present investigations research entitled “**Effect of growth retardants on growth and flowering of Chrysanthemum (*Chrysanthemum morifolium* Ramat.)**” was conducted at Research Farm, Department of Floriculture and Landscaping, Punjab Agricultural University, Ludhiana, during the year 2015-16. The research work was planned and conducted by keeping in view the following objectives:

- To standardize the optimum concentration of different growth retardants in chrysanthemum for plant architecture.
- To study the effect of different growth retardants on flowering parameters of chrysanthemum.

3.1 Geographical Location

District Ludhiana is located at 30° 54’ North (latitude) and 75° 48’ East (longitude) at the height of 247 m above the sea level.

3.2 Climate

The climatic zone of Ludhiana being subtropical is characterized by cold winters with occasional ground frost in the months of December and January and high temperature associated with hot desiccating winds in the month of May and June. The average rainfall of the area is 670.3 mm during 2015. The rains mainly occur during monsoon season with a few rain showers during winter season.

3.3 Plan of work

The experiment of the proposed research entitled “Effect of growth retardants on growth and flowering of Chrysanthemum (*Chrysanthemum morifolium* Ramat.)” was carried out as follows:

Location of work: Research Farm, Department of Floriculture and Landscaping, Punjab Agricultural University, Ludhiana

3.3.1 Plant Material

Varieties: Two (2)

- Anmol
- Royal purple

Anmol

It is a late flowering variety and requires 144 days for flowering. Plants are 50 cm tall. Flowers are bright yellow and anemone type. It is suitable for pot culture (Plate 1).



Plate 1: Chrysanthemum variety "Anmol"



Plate 2: Chrysanthemum variety "Royal purple"



Plate 3: Preparation of Chrysanthemum cuttings (a and b)



Plate 4: Preparation of potting media



Plate 5: Planting of rooted cutting in one pot

Royal purple

It is a late flowering variety and requires 141 days for flowering. Plants around 45 cm tall. Flowers are purplish pink and anemone type. It is suitable for pot culture (Plate 2).

Methodology

The healthy terminal stem cuttings (5-7 cm) free from symptoms of any disease or insect pest were taken in end of June for root formation and planted in propagation trays having burnt rice husk as rooting media (Plate 3). Roots were developed after 10 - 15 days and rooted cuttings were transplanted in the pots. The potting media was consist of Coco peat + Perlite + Vermiculite (3:1:1 v/v) (Plate 4) and planting of only one rooted cutting in one pot (Plate 5).

3.3.2 Application of Growth Retardants

The first application of growth retardants was applied after pinching i.e. 30 days after transplanting and another two applications were applied at 15 days interval. Control plants were sprayed with distilled water.

3.3.3 Experiment

Experiment I: Standardization of optimum concentration of growth retardants for plant architecture and flowering parameters of chrysanthemum.

Growth retardants: Three

- 1) CCC (Cycocel)
- 2) Daminozide
- 3) Ethephon

Treatments: Twelve

- | | | |
|-----------------|---|----------------------|
| T ₁ | : | Control |
| T ₂ | : | CCC @ 500ppm |
| T ₃ | : | CCC @ 750ppm |
| T ₄ | : | CCC @ 1000ppm |
| T ₅ | : | CCC @ 1250ppm |
| T ₆ | : | CCC @ 1500ppm |
| T ₇ | : | Daminozide @ 500ppm |
| T ₈ | : | Daminozide @ 750ppm |
| T ₉ | : | Daminozide @ 1000ppm |
| T ₁₀ | : | Ethephon @ 250ppm |
| T ₁₁ | : | Ethephon @ 500ppm |
| T ₁₂ | : | Ethephon @ 1000ppm |

Number of genotypes:	2 (Two)
Number of replications:	3 (Three)
Number of pots per replication:	10 (Ten)
Number of treatments:	12 (Twelve)
Experimental Design:	FCRD (Factorial Completely Randomized Design)

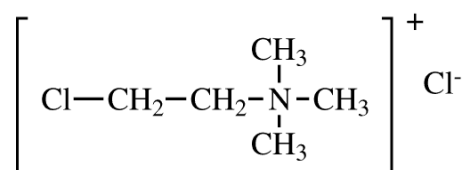
3.3.4 Cultural practices

Cultural operations like weeding, irrigation and management of insect pest and diseases were performed well in time according to the recommended package of practices of Punjab Agricultural University. Pinching was done in both the varieties at 4th and 7th week after transplanting. Staking was done by using sticks to keep the plants erect and maintain the proper shape of plant and bloom.

3.4 Growth retardants

3.4.1 CYCOCEL

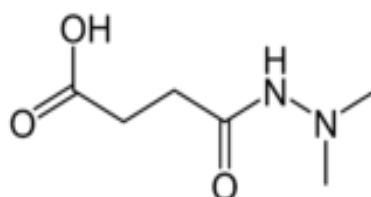
Cycocel is a plant growth regulator used for ornamentals, including bedding plants and herbaceous crops. Its chemical name is Chlormequat (2-chlorethyl) trimethyl ammonium chloride (Fig 1.) Chlormequat has active when applied to both the leaves and the roots but it is primarily applied as a foliar spray due to the higher concentrations required for adequate control when applied as a drench (Overbeek *et al* 1954).



Chemical structure of Chlormequat (2-chlorethyl) trimethyl ammonium chloride

3.4.2 DAMINOZIDE

Daminozide belongs to the group of B-nine and is a synthetic growth retardant. Its chemical name is N-(dimethylamine) succinamic acid (Fig 2.) This group is used in the ornamentals as a retardant which is responsible to inhibit the growth and flowering by blocking the gibberellin biosynthesis (Steffens 1980).

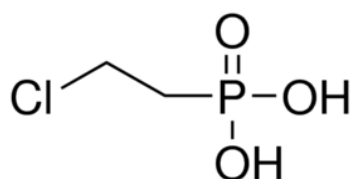


Chemical structure of B-9 [N- (dimethylamine) succinamic acid]

The properties of daminozide closely resemble those of chlormequat, which act by shortening and strengthening of stem in plants and foliage in certain species. It also causes sturdier plants with bushy growth which results in synchronized maturity and prevent premature fall and increases yield in ornamentals. In addition, it also increases the chlorophyll formation and the development of root system resulting in greater crop yield.

3.4.3 ETHEPHON

Ethephon is the most widely used plant growth regulator. Plants take up ethephon through the leaves where it is converted to ethylene in plant cells. Its chemical name is 2-Chloroethyl phosphonic acid. The increased ethylene causes cells to limit elongation (Overbeek *et al* 1954).



Chemical structure of 2-Chloroethyl phosphonic acid

3.4.1.1 Preparation of cycocel solution

A stock solution of 10,000 ppm was prepared by dissolving 10,000 mg of cycocel in 1 litre of distilled water and further dilutions were made as follows:

$$\text{Volume to be used} = \frac{\text{Concentration required}}{\text{Concentration given}} \times \text{Volume to be prepared}$$

Therefore, for preparing 500 ml of 500 ppm = $500 \times 500/1000 = 25$ ml of stock

Solution + 475 ml of distilled water. Similarly, 750, 1000, 1250 and 1500 ppm cycocel solutions were prepared.

3.4.2.2 Preparation of Daminozide solution

A stock solution of 10,000 ppm was prepared by dissolving 10,000 mg of B-9 in 1 litre of distilled water and further dilutions were made as follows:

$$\text{Volume to be used} = \frac{\text{Concentration required}}{\text{Concentration given}} \times \text{Volume to be prepared}$$

Therefore, for preparing 500 ml of 500 ppm = $500 \times 500/1000 = 25$ ml of stock

Solution + 475 ml of distilled water. Similarly, 750, 1000 ppm daminozide solutions were prepared.

3.4.3.3 Preparation of ethephon solution

A stock solution of 10,000 ppm was prepared by dissolving 10,000 mg of ethephon in 1 litre of distilled water and further dilutions were made as follows:

$$\text{Volume to be used} = \frac{\text{Concentration required}}{\text{Concentration given}} \times \text{Volume to be prepared}$$

Therefore, for preparing 500 ml of 500 ppm = $500 \times 500/1000 = 25$ ml of stock

Solution + 475 ml of distilled water. Similarly, 250, 1000 ppm ethephon solutions were prepared.

3.5 Observations

The observations were recorded on the vegetative and flowering characters:

3.5.1 Vegetative Parameters:

1. Plant height (cm)

Height of randomly selected five plants and their mean was calculated from each replication was recorded at the time of first bud appearance and plant height was recorded from ground level to the apical portion of longest shoot with help of meter scale.

2. Internodal length (cm)

The internodal length of plants was recorded from five randomly selected plants from each replication at the time of full bloom and their mean was calculated. Internodal length was recorded between the two nodes with the help of meter scale.

3. Diameter of main stem at flowering (mm)

Diameter of main stem was measured 5-8 cm above soil surface with the help of vernier caliper at full bloom stage.

4. Plant spread (cm)

The plant spread from top of the plant (length and width) of 10 selected plants from each replication was measured with the help of meter scale at the time of peak flowering and their average was calculated.

5. Leaf area

Leaf area was recorded at full bloom stage with the help of leaf area meter which is also called as sun scan instrument and it is unit less.

6. Leaf colour

The visual observations were recorded on leaf colour i.e dark green, green, light green in comparison to normal plant. Colour of the leaf was compared with the help of Royal Horticultural Society colour chart.

3.5.2 Flowering Parameters:

1. Days to bud appearance

The total number of days from date of transplanting to first bud appearance was calculated for five randomly selected plants from each replication and their average was worked out.

2. Days to colour break stage

Days to colour break stage was recorded for five randomly selected plants from date of transplanting when at least 50% of buds shows colour.

3. Days to full bloom stage

Days to full bloom was recorded for five randomly selected plants from date of transplanting till 50% of flowers were fully open.

4. Flower diameter (cm)

The flower size (length and width) of five randomly selected flowers on each plant was recorded with the help of measuring scale at the time of peak flowering and their average was calculated.

5. Number of flowers/plant

The total number of flowers was counted at the time of full bloom of five randomly selected plants per replication and their mean was calculated.

6. Duration of flowering

The number of days in which flower remain in full bloom is longevity. The five plants are randomly selected per replication and days are counted from flower opening till 50% of flowers dry.

3.6 Statistical Analysis

The experiments were conducted as per treatments in Factorial completely randomized design (FCRD) with three replications comprising ten pots per replication. The observations were recorded during 2015-2016. Data were subjected to statistical analysis by using CPCS-1, software developed by department of Mathematics and Statistics, Punjab Agricultural University, Ludhiana.

CHAPTER IV

RESULTS AND DISCUSSION

The present investigations entitled “Effect of growth retardants on growth and flowering of Chrysanthemum (*Chrysanthemum morifolium* Ramat.)” were carried out to standardize the optimum concentrations of different growth retardants in chrysanthemum for alteration of plant architecture and flowering parameters. The salient findings of present investigations are presented under the following headings:

4.1 Effect of different growth retardants on plant architecture of chrysanthemum

4.2 Effect of different growth retardants on flowering parameters of chrysanthemum

4.1 Effect of different growth retardants on plant architecture of chrysanthemum

4.1.1 Plant height (cm)

The perusal of data depicted in Table 4.1.1 and Fig. 4.1.1 reveals that the plant height was significantly affected with different concentrations of growth retardants. Among different growth retardants treatments tried, the maximum plant height (26.17 cm) was obtained in control plants where no spray was done, followed by treatment comprising CCC @ 500 ppm showing 25.23 cm plant height.

Table 4.1.1: Effect of growth retardants on plant height at the time of first bud appearance in chrysanthemum cvs. Anmol and Royal Purple

Treatments	Varieties		Mean
	Anmol	Royal Purple	
Control	27.09	25.24	26.17
CCC @ 500ppm	25.46	25.00	25.23
CCC @ 750ppm	25.18	24.30	24.74
CCC @ 1000ppm	25.04	24.19	24.61
CCC @ 1250ppm	24.77	23.10	23.94
CCC @ 1500ppm	24.92	22.83	23.87
Daminozide @ 500ppm	25.34	23.84	24.59
Daminozide @ 750ppm	24.81	23.52	24.17
Daminozide @ 1000ppm	24.13	22.29	23.21
Ethephon @ 250ppm	25.20	24.89	25.04
Ethephon @ 500ppm	25.14	22.91	24.03
Ethephon @ 1000ppm	24.48	22.50	23.49
Mean	25.13	23.72	

CD at 5%

Treatment (T)	0.57
Genotype (G)	1.41
Treatment x Genotype (TxG)	NS



**Plate 6: Plant height at first bud appearance in cv. Anmol
(a) Control (b) Daminozide @ 1000 ppm**



**Plate 7: Plant height at first bud appearance in cv. Royal Purple
(a) Control (b) Daminozide @ 1000 ppm**

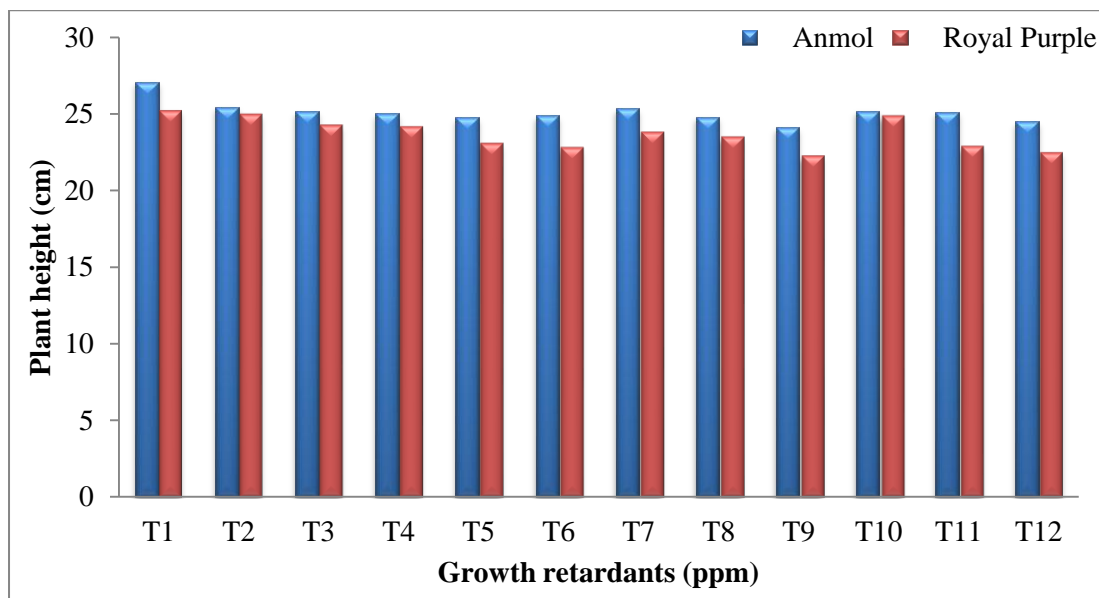


Fig. 4.1.1: Effect of growth retardants on plant height at the time of first bud appearance in chrysanthemum cvs. Anmol and Royal Purple

T₁: Control

T₂: CCC @ 500ppm

T₃: CCC @ 750ppm

T₄: CCC @ 1000ppm

T₅: CCC @ 1250ppm

T₆: CCC @ 1500ppm

T₇: Daminozide @ 500ppm

T₈: Daminozide @ 750ppm

T₉: Daminozide @ 1000ppm

T₁₀: Ethephon @ 250ppm

T₁₁: Ethephon @ 500ppm

T₁₂: Ethephon @ 1000ppm

The minimum plant height (23.21 cm) was obtained with growth retardant treatment daminozide @ 1000 ppm followed by second lowest plant height (23.49 cm) with ethephon @ 1000 ppm treatment. All these treatments differed significantly with each other with respect to plant height.

Irrespective of the treatments, the two genotypes Anmol and Royal Purple also differed significantly. The maximum plant height (25.13 cm) was recorded in cv. Anmol, as compared to (23.72 cm) plant height in cv. Royal Purple. The interaction effect of two factors was found non-significant. In cv. Anmol minimum plant height (24.13cm) was found in treatment comprising daminozide @ 1000 ppm which was statistically at par with treatment ethephon @ 1000 ppm (24.48 cm) while maximum plant height (27.09 cm) was recorded in control where no spray of growth retardants was done (Plate 6). Similarly in cv. Royal Purple minimum plant height (22.29 cm) and maximum plant height (25.24 cm) was recorded in same treatments as that of cv. Anmol (Plate 7).

The significant reduction in plant height is in close conformity with the findings of Kim *et al* (2010), when B-9 (daminozide) @ 800 ppm was applied as foliar spray on (*Chrysanthemum morifolium* Ramat.) and Haque *et al* (2007), when ethrel @ 250, 500 ppm and cycocel @ 1000, 2000 ppm was applied on (*Chrysanthemum cinerariaefolium* Vis.). The reduction in plant height with B-9 (daminozide), Cycocel and Ethephon application might be

due to inhibitory role of growth retardants on cell division and cell elongation of apical meristematic cells and also on the GA₃ bio-synthesis (Cathey 1964, 1975). It is well known that increase in height of a plant is a result of endogenous GA level, but B-9(daminozide) is well known inhibitor of gibberellins biosynthesis as it specifically inhibits the microsomal oxidation of ent-kaurene in the isoprenoid pathway of GA- biosynthesis (Davis *et al* 1988).

4.1.2 Internodal length (cm)

The data pertaining in Table 4.1.2 and Fig. 4.1.2 reveals that the internodal length was significantly affected with different concentrations of growth retardants. Among different growth retardants treatments tried, the maximum internodal length (5.17 cm) was obtained in control plants where no spray was done, followed by treatment comprising CCC @ 500 ppm showing 4.73 cm internodal length. The minimum internodal length (3.34 cm) was obtained with growth retardant treatment daminozide @ 1000 ppm followed by second lowest internodal length (3.76 cm) with ethephon @ 1000 ppm treatment. All these treatments differed significantly with each other with respect to internodal length.

Table 4.1.2: Effect of growth retardants on Internodal length (cm) in chrysanthemum cvs. Anmol and Royal Purple

Treatments	Varieties		Mean
	Anmol	Royal Purple	
Control	5.12	5.21	5.17
CCC @ 500ppm	4.61	4.85	4.73
CCC @ 750ppm	4.53	4.70	4.61
CCC @ 1000ppm	4.50	4.50	4.50
CCC @ 1250ppm	4.35	4.21	4.28
CCC @ 1500ppm	4.21	4.13	4.17
Daminozide @ 500ppm	3.86	4.05	3.96
Daminozide @ 750ppm	3.73	3.91	3.82
Daminozide @ 1000ppm	3.20	3.48	3.34
Ethephon @ 250ppm	4.28	4.06	4.17
Ethephon @ 500ppm	4.07	4.05	4.06
Ethephon @ 1000ppm	3.79	3.73	3.76
Mean	4.19	4.24	

CD at 5%

Treatment (T)	0.30
Genotype (G)	NS
Treatment x Genotype (TxG)	NS

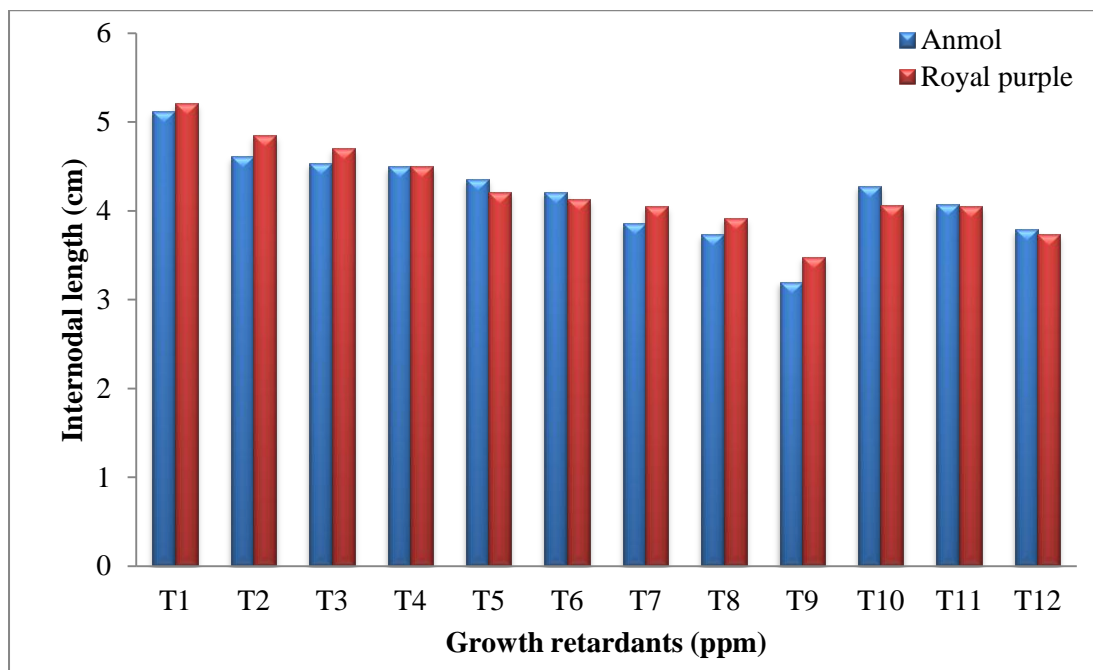


Fig. 4.1.2: Effect of growth retardants on Internodal length (cm) in chrysanthemum cvs. Anmol and Royal Purple

T₁ : Control	T₂ : CCC @ 500ppm	T₃ : CCC @ 750ppm
T₄ : CCC @ 1000ppm	T₅ : CCC @ 1250ppm	T₆ : CCC @ 1500ppm
T₇ : Daminozide @ 500ppm	T₈ : Daminozide @ 750ppm	T₉ : Daminozide @ 1000ppm
T₁₀ : Ethephon @ 250ppm	T₁₁ : Ethephon @ 500ppm	T₁₂ : Ethephon @ 1000ppm

The two genotypes Anmol and Royal Purple was found non-significant with each other. The interaction effect of two factors was also found non-significant. In cv. Anmol minimum intermodal length (3.20 cm) was found in treatment comprising daminozide @ 1000 ppm which was statistically at par with treatment daminozide @ 750 ppm while maximum intermodal length (5.12 cm) was recorded in control where no spray of growth retardants was done. Similarly in cv. Royal Purple minimum intermodal length (3.48 cm) and maximum intermodal length (5.21 cm) was recorded in same treatments as that of cv. Anmol.

Similar to our findings results have been reported by Moond *et al* (2006) and Zalewaska (1989), when growth retardant Alar was applied @ concentrations (1250, 2500, 5000 mg/l) and he revealed that Alar concentration 5000 mg/l had the biggest dwarfing effect on chrysanthemum. El-Shortening of intermodal length has also been reported by Gad *et al* (1997). The reduction in intermodal length with B-9 (daminozide), Cycocel and Ethephon application might be due to inhibitory role of growth retardants on cell division and cell elongation of apical meristematic cells and also on the GA₃ bio-synthesis (Cathey 1964, 1975). Due to the reducing level of endogenous GA₃, which ultimately leads to the shortening of internodes.

4.1.3 Diameter of main stem at flowering (mm)

Diameter of main stem at flowering was significantly affected with different concentrations of growth retardants as depicted in Table 4.1.3 and Fig. 4.1.3. Among different growth retardants treatments tried, the maximum (5.93 mm) diameter of main stem at flowering was obtained in daminozide @ 1000 ppm, followed by treatment comprising daminozide @ 750 ppm showing 5.60 mm diameter of main stem. The minimum diameter of main stem (4.04 mm) was obtained in control plants, where no spray of growth retardants was done. All these treatments differed significantly with each other with respect to diameter of main stem.

Irrespective of the treatments, the two genotypes Anmol and Royal Purple also differed significantly. The maximum diameter of main stem (5.17 mm) was recorded in cv. Royal Purple, as compared to (4.96 mm) diameter of main stem in cv. Anmol. The interaction effect of two factors was found significant. In cv. Anmol maximum diameter of main stem (5.90 mm) was found in treatment comprising daminozide @ 1000 ppm which was statistically at par with treatment daminozide @ 750 ppm (5.56 mm) while minimum diameter of main stem (4.01 mm) was recorded in control where no spray of growth retardants was done. Similarly in cv. Royal Purple maximum diameter of main stem (5.97 mm) and minimum diameter of main stem (4.07 mm) was recorded in same treatments as that of cv. Anmol.

Table 4.1.3: Effect of growth retardants on diameter of main stem at flowering (mm) in chrysanthemum cvs. Anmol and Royal Purple

Treatments	Varieties		Mean
	Anmol	Royal Purple	
Control	4.01	4.07	4.04
CCC @ 500ppm	4.22	4.68	4.45
CCC @ 750ppm	4.44	4.92	4.68
CCC @ 1000ppm	4.64	5.00	4.82
CCC @ 1250ppm	4.76	5.08	4.92
CCC @ 1500ppm	4.95	5.11	5.03
Daminozide @ 500ppm	5.11	5.23	5.17
Daminozide @ 750ppm	5.56	5.65	5.60
Daminozide @ 1000ppm	5.90	5.97	5.93
Ethephon @ 250ppm	5.22	5.31	5.26
Ethephon @ 500ppm	5.32	5.47	5.39
Ethephon @ 1000ppm	5.45	5.59	5.52
Mean	4.96	5.17	
CD at 5%			
Treatment (T)	0.80		
Genotype (G)	0.32		
Treatment x Genotype (TxG)	0.11		

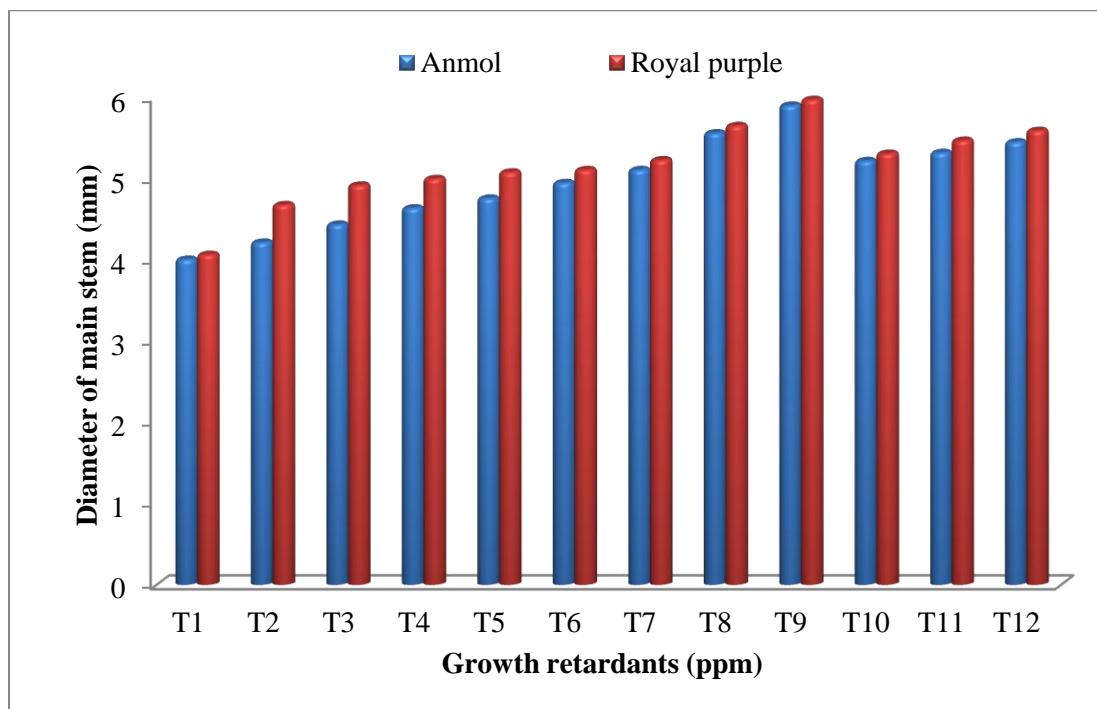


Fig. 4.1.3: Effect of growth retardants on diameter of main stem at flowering (mm) in chrysanthemum cvs. Anmol and Royal Purple

T₁ : Control	T₂ : CCC @ 500ppm	T₃ : CCC @ 750ppm
T₄ : CCC @ 1000ppm	T₅ : CCC @ 1250ppm	T₆ : CCC @ 1500ppm
T₇ : Daminozide @ 500ppm	T₈ : Daminozide @ 750ppm	T₉ : Daminozide @ 1000ppm
T₁₀ : Ethephon @ 250ppm	T₁₁ : Ethephon @ 500ppm	T₁₂ : Ethephon @ 1000ppm

The effect of growth retardants on significant increase in the diameter of main stem has been reported earlier by Kim *et al* (2010), El-Sheibany *et al* (2007), when growth retardant Alar (daminozide) was applied as a foliar spray on (*Chrysanthemum morifolium* Ramat.) @ 1250, 2500 and 5000 ppm.

4.1.4 Plant spread (cm)

The perusal of data depicted in Table 4.1.4 and Fig. 4.1.4 reveals that the plant spread was significantly affected with different concentrations of growth retardants. Among different growth retardants treatments tried, the maximum (16.88 cm) plant spread was obtained in daminozide @ 1000 ppm, followed by treatment comprising ethephon @ 1000 ppm showing 16.64 cm plant spread. The minimum plant spread (13.94 cm) was obtained in control plants, where no spray of growth retardants was done. All these treatments differed significantly with each other with respect to plant spread.

Irrespective of the treatments, the two genotypes Anmol and Royal Purple also differed significantly. The maximum plant spread (16.73 cm) was recorded in cv. Royal

Purple, as compared to (14.83 cm) plant spread in cv. Anmol. The interaction effect of two factors was found significant. In cv. Anmol maximum plant spread (15.36 cm) was found in treatment comprising daminozide @ 1000 ppm which was statistically at par with treatment CCC @ 1250 ppm (15.29 cm) while minimum plant spread (13.07 cm) was recorded in control where no spray of growth retardants was done. Similarly in cv. Royal Purple maximum plant spread (18.40 cm) and minimum plant spread (14.80 cm) was recorded in same treatments as that of cv. Anmol.

The significant increase in plant spread is in close conformity with the findings of Navale *et al* (2010), Naidu *et al* (2014), when CCC (Cycocel) was applied @ 750, 1000 and 1250 ppm and Karlovic *et al* (2004), when growth retardants Alar (daminozide) @ 1000, 2000 and 3000mg/L and chloromequet (cycocel) @ 2000, 3000, 4000mg/L were applied on chrysanthemum cv. Revert. The increased plant spread might be due the increase in the number of branches per plant in terms of both N-S and E-W and thereby increased plant spread.

Table 4.1.4: Effect of growth retardants on plant spread (cm) in chrysanthemum cvs. Anmol and Royal Purple

Treatments	Varieties		Mean
	Anmol	Royal Purple	
Control	13.07	14.80	13.94
CCC @ 500ppm	14.22	15.12	14.67
CCC @ 750ppm	14.67	15.43	15.05
CCC @ 1000ppm	14.70	15.90	15.30
CCC @ 1250ppm	15.29	16.10	15.69
CCC @ 1500ppm	15.23	16.86	16.04
Daminozide @ 500ppm	14.90	17.11	16.01
Daminozide @ 750ppm	15.20	17.74	16.47
Daminozide @ 1000ppm	15.36	18.40	16.88
Ethephon @ 250ppm	14.95	17.61	16.28
Ethephon @ 500ppm	15.10	17.64	16.37
Ethephon @ 1000ppm	15.25	18.04	16.64
Mean	14.83	16.73	

CD at 5%

Treatment (T)	0.36
Genotype (G)	0.14
Treatment x Genotype (TxG)	0.51

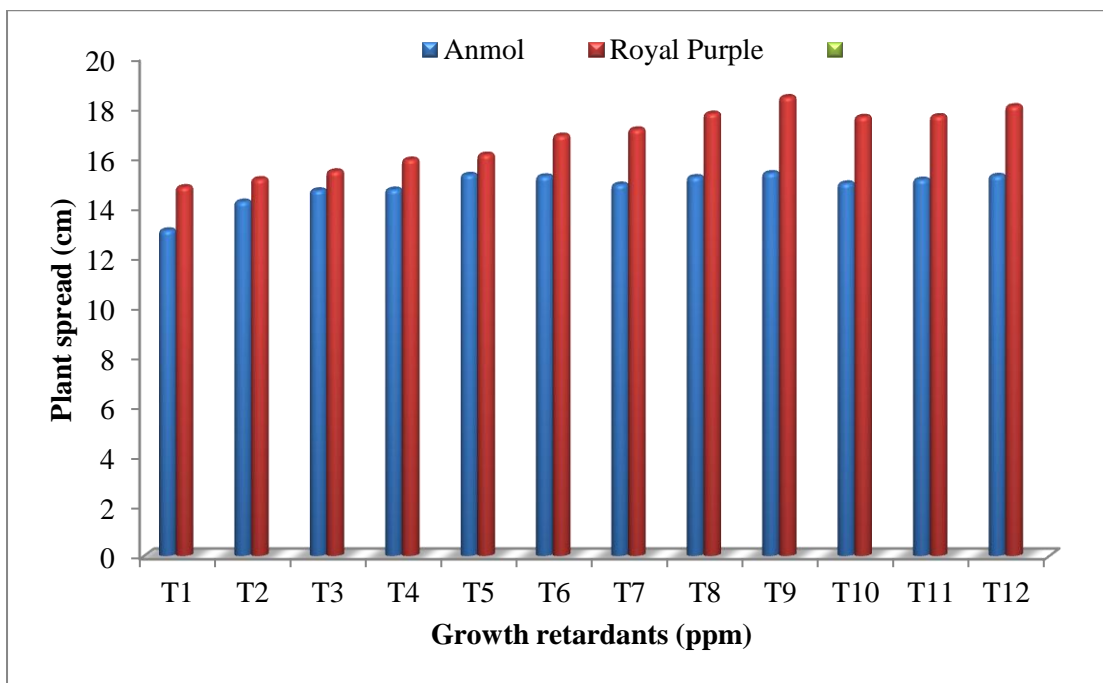


Fig. 4.1.4: Effect of growth retardants on plant spread (cm) in chrysanthemum cvs. Anmol and Royal Purple

T ₁ : Control	T ₂ : CCC @ 500ppm	T ₃ : CCC @ 750ppm
T ₄ : CCC @ 1000ppm	T ₅ : CCC @ 1250ppm	T ₆ : CCC @ 1500ppm
T ₇ : Daminozide @ 500ppm	T ₈ : Daminozide @ 750ppm	T ₉ : Daminozide @ 1000ppm
T ₁₀ : Ethephon @ 250ppm	T ₁₁ : Ethephon @ 500ppm	T ₁₂ : Ethephon @ 1000ppm

4.1.5 Leaf area

The leaf area was significantly affected with different concentrations of growth retardants as pertaining in Table 4.1.5 and Fig. 4.1.5. Among different growth retardants treatments tried, the maximum (2.30) leaf area was obtained in daminozide @ 1000 ppm, followed by treatment comprising daminozide @ 750 ppm showing 2.19 leaf area. The minimum leaf area (0.78) was obtained in control plants, where no spray of growth retardants was done. All these treatments differed significantly with each other with respect to leaf area.

Irrespective of the treatments, the two genotypes Anmol and Royal Purple also differed significantly. The maximum leaf area (2.13) was recorded in cv. Anmol, as compared to (1.51) leaf area in cv. Royal Purple. The interaction effect of two factors was found significant. In cv. Anmol maximum leaf area (2.66) was found in treatment comprising daminozide @ 1000 ppm which was statistically at par with treatment daminozide @ 750 ppm (2.59) while minimum leaf area (1.03) was recorded in control, where no spray of growth retardants was done. Similarly in cv. Royal Purple maximum leaf area (1.93) and minimum leaf area (0.53) was recorded in same treatments as that of cv. Anmol.

Table 4.1.5: Effect of growth retardants on leaf area in chrysanthemum cvs. Anmol and Royal Purple

Treatments	Varieties		Mean
	Anmol	Royal Purple	
Control	1.03	0.53	0.78
CCC @ 500ppm	1.36	1.10	1.23
CCC @ 750ppm	1.73	1.20	1.46
CCC @ 1000ppm	1.86	1.65	1.75
CCC @ 1250ppm	2.55	1.72	2.13
CCC @ 1500ppm	2.60	1.77	2.18
Daminozide @ 500ppm	2.01	1.59	1.80
Daminozide @ 750ppm	2.59	1.80	2.19
Daminozide @ 1000ppm	2.66	1.93	2.30
Ethephon @ 250ppm	2.33	1.50	1.91
Ethephon @ 500ppm	2.40	1.63	2.01
Ethephon @ 1000ppm	2.52	1.70	2.11
Mean	2.13	1.51	

CD at 5%

Treatment (T) 0.75

Genotype (G) 0.30

Treatment x Genotype (TxG) 0.10

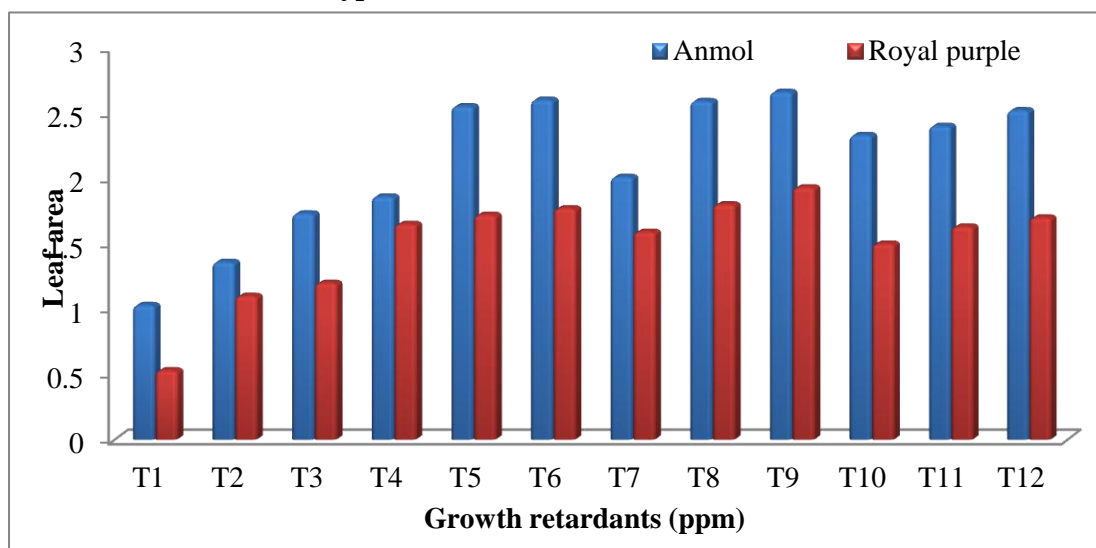


Fig. 4.1.5: Effect of growth retardants on leaf area in chrysanthemum cvs. Anmol and Royal Purple

T₁: Control

T₂: CCC @ 500ppm

T₃: CCC @ 750ppm

T₄: CCC @ 1000ppm

T₅: CCC @ 1250ppm

T₆: CCC @ 1500ppm

T₇: Daminozide @ 500ppm

T₈: Daminozide @ 750ppm

T₉: Daminozide @ 1000ppm

T₁₀: Ethephon @ 250ppm

T₁₁: Ethephon @ 500ppm

T₁₂: Ethephon @ 1000ppm

Similar to our findings increase in leaf area have been reported by Moond *et al* (2006), El-sheibany *et al* (2008), Hashemabadi *et al* (2012) and Asrar *et al* (2014), when B-9 (daminozide) was applied as foliar spray on (*Chrysanthemum morifolium* Ramat.) @ 1500, 3000 and 4500 ppm.

4.1.6 Leaf colour

Based on visual observations leaf colour was recorded i.e dark green, green, light green in comparison to normal plant. Colour of the leaf was also compared with the help of Royal Horticultural Society colour chart. The Table 4.1.6 shows that colour of leaves in all the treatments where CCC (cycocel), daminozide and ethephon were sprayed was darker green as compared to control.

Table 4.1.6: Effect of growth retardants on leaf colour in chrysanthemum cvs. Anmol and Royal Purple

Treatments	Varieties		Visual observations
	Anmol	Royal Purple	
	Leaf colour as par R.H.S. Colour Chart		
Control	Yellow Green Group 145 B	Yellow Green Group 145 B	Light green
CCC @ 500ppm	Yellow Green Group 146 A	Yellow Green Group 146 A	Light green
CCC @ 750ppm	Yellow Green Group 146 A	Yellow Green Group 146 A	Light green
CCC @ 1000ppm	Yellow Green Group 146 A	Yellow Green Group 146 A	Light green
CCC @ 1250ppm	Yellow Green Group 146 A	Yellow Green Group 146 A	Light green
CCC @ 1500ppm	Yellow Green Group 146 A	Yellow Green Group 146 A	Light green
Daminozide @ 500ppm	Green 137 B	Green 137 B	Dark green
Daminozide @ 750ppm	Green 137 B	Green 137 B	Dark green
Daminozide @1000ppm	Green 137 B	Green 139 B	Dark green
Ethephon @ 250ppm	Green 138 B	Green 139 B	Green
Ethephon @ 500ppm	Green 138 B	Green 139 B	Green
Ethephon @ 1000ppm	Green 138 B	Green 139 B	Green

Application of triazole plant growth regulators commonly produces plants with darker green leaves than untreated plants and this greening effect of triazole is the result of increased concentration of chlorophyll (Wang and Gregg 1994). Similar to our findings results have been reported by El-sheibany *et al* (2008), when growth retardant Alar was applied @ 1250, 2500 and 500 mg/l. Results showed that due to change in the number of palisade cells treated

leaves were normal in shape but with reduction in the leaf area associated with darker green colour.

4.2 Effect of different growth retardants on flowering parameters of chrysanthemum

4.2.1 Days to bud appearance

The days to bud appearance was significantly affected with different concentrations of growth retardants as depicted in Table 4.2.1 and Fig. 4.2.1. Among different growth retardants treatments tried, the maximum (87.30) days to bud appearance was obtained in ethephon @ 1000 ppm, followed by treatment comprising ethephon @ 500 ppm showing 87.16 days to bud appearance. The minimum days to bud appearance (82.16 days) was obtained in treatment comprising daminozide @ 1000 ppm followed by second lowest (83.43 days) was found in daminozide @ 750 ppm. All these treatments differed significantly with each other with respect to days to bud appearance.

Table 4.2.1: Effect of growth retardants on days to bud appearance in chrysanthemum cvs. Anmol and Royal Purple

Treatments	Varieties		Mean
	Anmol	Royal Purple	
Control	84.26	87.40	85.83
CCC @ 500ppm	84.76	87.46	86.11
CCC @ 750ppm	84.90	87.50	86.20
CCC @ 1000ppm	85.13	87.60	86.36
CCC @ 1250ppm	85.50	87.83	86.66
CCC @ 1500ppm	85.63	88.00	86.81
Daminozide @ 500ppm	82.86	84.70	83.78
Daminozide @ 750ppm	82.60	84.26	83.43
Daminozide @ 1000ppm	80.56	83.76	82.16
Ethephon @ 250ppm	85.76	88.13	86.95
Ethephon @ 500ppm	86.00	88.33	87.16
Ethephon @ 1000ppm	86.06	88.53	87.30
Mean	84.50	86.96	
CD at 5%			
Treatment (T)			0.63
Genotype (G)			0.26
Treatment x Genotype (TxG)			NS

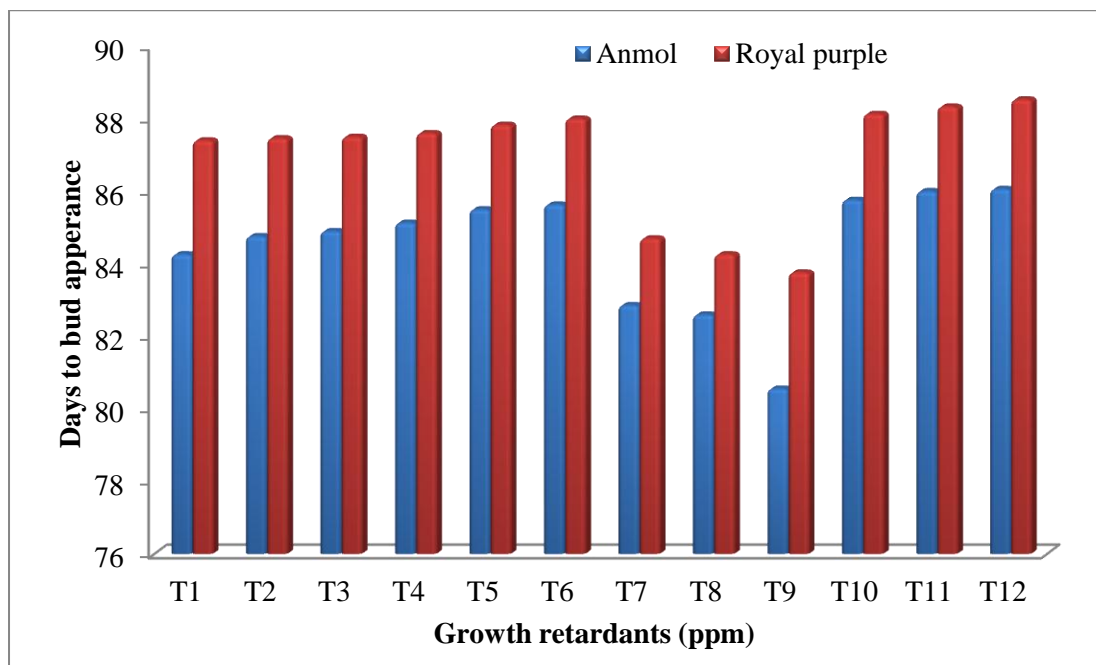


Fig. 4.2.1: Effect of growth retardants on days to bud appearance in chrysanthemum cvs. Anmol and Royal Purple

T₁ : Control	T₂ : CCC @ 500ppm	T₃ : CCC @ 750ppm
T₄ : CCC @ 1000ppm	T₅ : CCC @ 1250ppm	T₆ : CCC @ 1500ppm
T₇ : Daminozide @ 500ppm	T₈ : Daminozide @ 750ppm	T₉ : Daminozide @ 1000ppm
T₁₀ : Ethephon @ 250ppm	T₁₁ : Ethephon @ 500ppm	T₁₂ : Ethephon @ 1000ppm

Irrespective of the treatments, the two genotypes Anmol and Royal Purple also differed significantly. The maximum days to bud appearance (86.96 days) was recorded in cv. Royal Purple, as compared to (84.50) days to bud appearance in cv. Anmol. The interaction effect of two factors was found non-significant. In cv. Anmol minimum days to bud appearance (80.56 days) was found in treatment comprising daminozide @ 1000 ppm while maximum days to bud appearance (86.06 days) was recorded in treatment comprising ethephon @ 1000 ppm. Similarly in cv. Royal Purple minimum days to bud appearance (83.76 days) and maximum days to bud appearance (88.53 days) was recorded in same treatments as that of cv. Anmol.

The significant reduction in days to bud appearance is in close conformity with the findings of kahar (2008), Kazaz *et al* (2010), Asrar *et al* (2014), when growth retardant Alar (daminozide) @ 1500 ppm was applied as a foliar spray on chrysanthemum cvs. Kodiak ‘yellow’, Ivyridgf ‘white’, Auburn ‘red’ and Lansing ‘pink’.

4.2.2 Days to colour break stage

The perusal of data depicted in Table 4.2.2 and Fig. 4.2.2 reveals that the days to colour break stage was significantly affected with different concentrations of growth retardants. Among different growth retardants treatments tried, the maximum (108.53) days to colour

break stage was obtained in ethephon @ 1000 ppm, followed by treatment comprising ethephon @ 500 ppm showing 108.28 days to colour break stage. The minimum days to colour break stage (104.71 days) was obtained in treatment comprising daminozide @ 1000 ppm followed by second lowest (104.95 days) was found in daminozide @ 750 ppm. All these treatments differed significantly with each other with respect to days to colour break stage.

Irrespective of the treatments, the two genotypes Anmol and Royal Purple also differed significantly. The maximum days to colour break stage (107.95 days) was recorded in cv. Royal Purple, as compared to (106.08) days to colour break stage in cv. Anmol. The interaction effect of two factors was found non-significant. In cv. Anmol minimum days to colour break stage (103.66 days) was found in treatment comprising daminozide @ 1000 ppm which was statistically at par with treatment daminozide @ 750 ppm (103.80 days) while maximum days to colour break stage (107.73 days) was recorded in treatment comprising ethephon @ 1000 ppm. Similarly in cv. Royal Purple minimum days to colour break stage (105.76 days) and maximum days to colour break stage (109.33 days) was recorded in same treatments as that of cv. Anmol.

Table 4.2.2: Effect of growth retardants on days to colour break stage in chrysanthemum cvs. Anmol and Royal Purple

Treatments	Varieties		Mean
	Anmol	Royal Purple	
Control	106.03	107.76	106.89
CCC @ 500ppm	106.20	108.13	107.16
CCC @ 750ppm	106.33	108.20	107.26
CCC @ 1000ppm	106.40	108.33	107.36
CCC @ 1250ppm	106.86	108.70	107.78
CCC @ 1500ppm	107.10	108.83	107.96
Daminozide @ 500ppm	104.06	106.36	105.21
Daminozide @ 750ppm	103.80	106.10	104.95
Daminozide @ 1000ppm	103.66	105.76	104.71
Ethephon @ 250ppm	107.23	108.86	108.04
Ethephon @ 500ppm	107.53	109.03	108.28
Ethephon @ 1000ppm	107.73	109.33	108.53
Mean	106.08	107.95	
CD at 5%			
Treatment (T)			0.25
Genotype (G)			0.10
Treatment x Genotype (TxG)			0.36

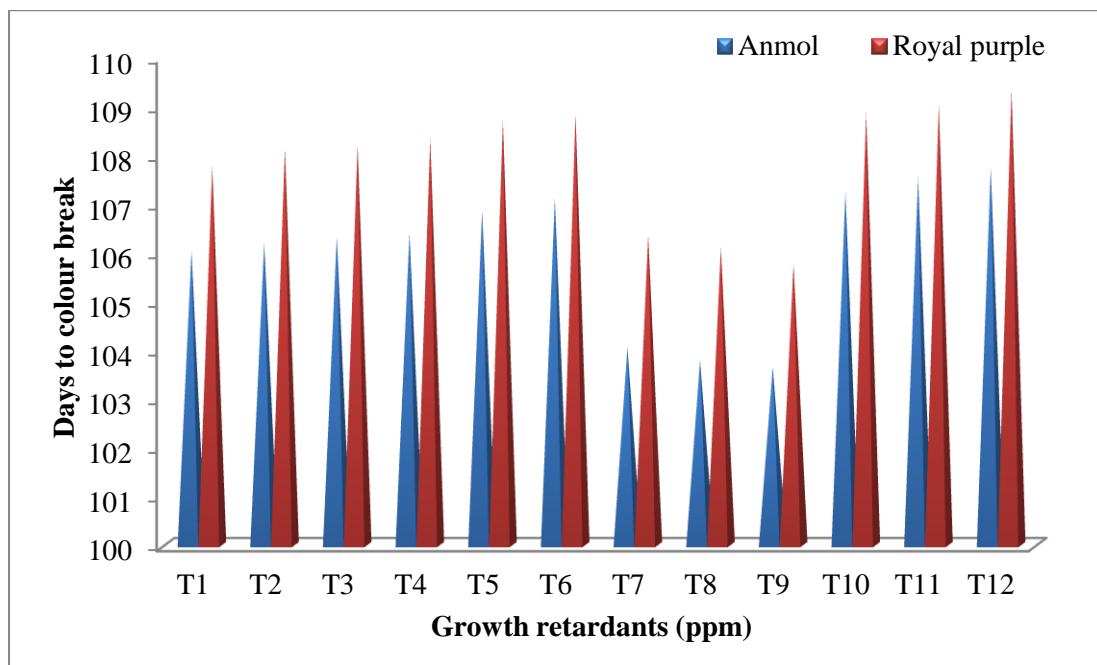


Fig. 4.2.2: Effect of growth retardants on days to colour break stage in chrysanthemum cvs. Anmol and Royal Purple

T₁ : Control	T₂ : CCC @ 500ppm	T₃ : CCC @ 750ppm
T₄ : CCC @ 1000ppm	T₅ : CCC @ 1250ppm	T₆ : CCC @ 1500ppm
T₇ : Daminozide @ 500ppm	T₈ : Daminozide @ 750ppm	T₉ : Daminozide @ 1000ppm
T₁₀ : Ethephon @ 250ppm	T₁₁ : Ethephon @ 500ppm	T₁₂ : Ethephon @ 1000ppm

Similar to our findings results have been reported by Asrar *et al* (2014), when growth retardant Alar (daminozide) @ 1500 ppm was applied as a foliar spray on chrysanthemum cvs. Kodiak ‘yellow’, Ivyridgf ‘white’, Auburn ‘red’ and Lansing ‘pink’.

4.2.3 Days to full bloom stage

The data pertaining in Table 4.2.3 and Fig. 4.2.3 reveals that the days to full bloom stage was significantly affected with different concentrations of growth retardants. Among different growth retardants treatments tried, the maximum (129.98) days to full bloom stage was obtained in ethephon @ 1000 ppm, followed by treatment comprising ethephon @ 500 ppm showing 129.78 days to full bloom stage. The minimum days to full bloom stage (124.41 days) was obtained in treatment comprising daminozide @ 1000 ppm followed by second lowest (124.86 days) was found in daminozide @ 750 ppm. All these treatments differed significantly with each other with respect to days to full bloom stage.

Table 4.2.3: Effect of growth retardants on days to full bloom stage in chrysanthemum cvs. Anmol and Royal Purple

Treatments	Varieties		Mean
	Anmol	Royal Purple	
Control	126.26	129.13	127.7
CCC @ 500ppm	126.63	129.16	127.9
CCC @ 750ppm	126.83	129.33	128.08
CCC @ 1000ppm	126.93	129.66	128.3
CCC @ 1250ppm	127.33	130.06	128.7
CCC @ 1500ppm	127.50	130.36	128.93
Daminozide @ 500ppm	124.50	125.90	125.2
Daminozide @ 750ppm	124.03	125.70	124.86
Daminozide @ 1000ppm	123.56	125.26	124.41
Ethephon @ 250ppm	128.06	130.63	129.35
Ethephon @ 500ppm	128.56	131.00	129.78
Ethephon @ 1000ppm	128.73	131.23	129.98
Mean	126.58	128.95	

CD at 5%

Treatment (T)	0.29
Genotype (G)	0.12
Treatment x Genotype (TxG)	0.41

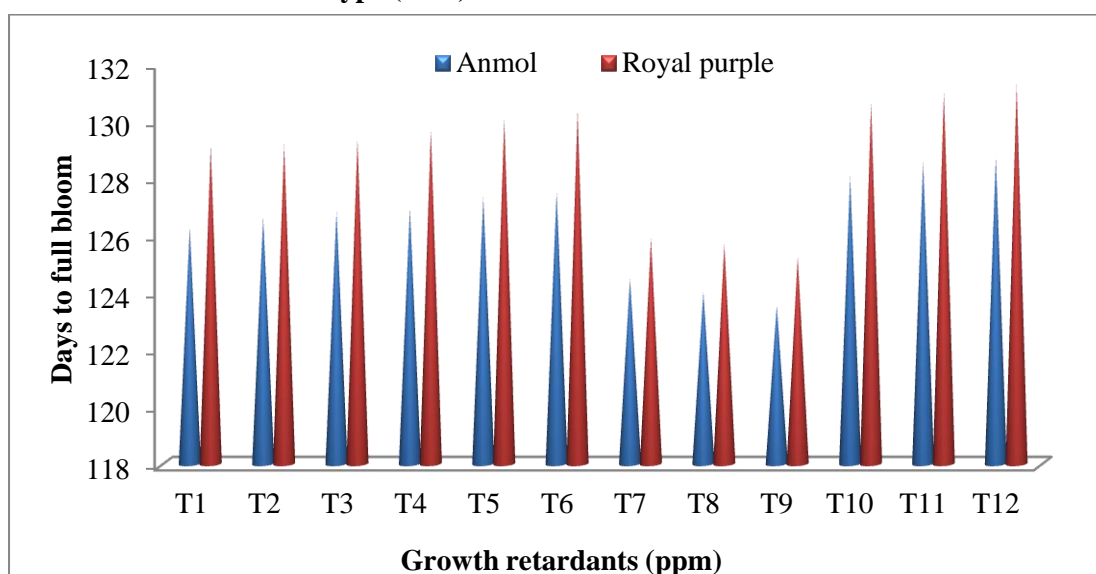


Fig. 4.2.3: Effect of growth retardants on days to full bloom stage in chrysanthemum cvs. Anmol and Royal Purple

T ₁ : Control	T ₂ : CCC @ 500ppm	T ₃ : CCC @ 750ppm
T ₄ : CCC @ 1000ppm	T ₅ : CCC @ 1250ppm	T ₆ : CCC @ 1500ppm
T ₇ : Daminozide @ 500ppm	T ₈ : Daminozide @ 750ppm	T ₉ : Daminozide @ 1000ppm
T ₁₀ : Ethephon @ 250ppm	T ₁₁ : Ethephon @ 500ppm	T ₁₂ : Ethephon @ 1000ppm

Irrespective of the treatments, the two genotypes Anmol and Royal Purple also differed significantly. The maximum days to full bloom stage (128.95 days) was recorded in cv. Royal Purple, as compared to (126.58) days to full bloom stage in cv. Anmol. The interaction effect of two factors was found significant. In cv. Anmol minimum days to full bloom stage (123.56 days) was found in treatment comprising daminozide @ 1000 ppm while maximum days to full bloom stage (128.73 days) was recorded in treatment comprising ethephon @ 1000 ppm. Similarly in cv. Royal Purple minimum days to full bloom stage (125.26 days) and maximum days to full bloom stage (131.23 days) was recorded in same treatments as that of cv. Anmol.

The effect of growth retardants on days to full bloom stage has been reported earlier by Kahar (2008), Asrar *et al* (2014), when growth retardant Alar (daminozide) @ 1500 ppm was applied as a foliar spray on chrysanthemum cvs. Kodiak 'yellow', Ivyridgf 'white', Auburn 'red' and Lansing 'pink'. The days to full bloom stage in daminozide was minimum could be due to modifying activity in the cambium, thus, resulting in abnormal type of cells in the xylem and the disappearance of sclerenchymatous cells adjacent to the cortex. The restriction of growth presumably alters the metabolism thereby creating conditions conducive for flower initiation (Cathey 1964).

4.2.4 Flower diameter (cm)

The perusal of data depicted in Table 4.2.4 and Fig. 4.2.4 reveals that the flower diameter was significantly affected with different concentrations of growth retardants. Among different growth retardants treatments tried, the maximum (5.77 cm) flower diameter was obtained in daminozide @ 500 ppm, followed by treatment comprising ethephon @ 250 ppm showing 5.60 cm flower diameter. The minimum flower diameter (4.14 cm) was obtained in control plants, where no spray of growth retardants was done. All these treatments differed significantly with each other with respect to flower diameter.

Irrespective of the treatments, the two genotypes Anmol and Royal Purple also differed significantly. The maximum flower diameter (5.32 cm) was recorded in cv. Royal Purple, as compared to (4.90 cm) flower diameter in cv. Anmol. The interaction effect of two factors was found non-significant. In cv. Anmol maximum flower diameter (5.69 cm) was found in treatment comprising daminozide @ 500 ppm while minimum flower diameter (3.76 cm) was recorded in control plants, where no spray of growth retardants was done. Similarly in cv. Royal Purple maximum flower diameter (5.86 cm) and minimum flower diameter (4.52 cm) was recorded in same treatments as that of cv. Anmol.

Table 4.2.4: Effect of growth retardants on flower diameter (cm) in chrysanthemum cvs. Anmol and Royal Purple

Treatments	Varieties		Mean
	Anmol	Royal Purple	
Control	3.76	4.52	4.14
CCC @ 500ppm	4.94	5.23	5.08
CCC @ 750ppm	4.80	5.16	4.98
CCC @ 1000ppm	4.73	5.10	4.91
CCC @ 1250ppm	4.62	4.98	4.80
CCC @ 1500ppm	4.35	4.93	4.64
Daminozide @ 500ppm	5.69	5.86	5.77
Daminozide @ 750ppm	5.21	5.62	5.41
Daminozide @ 1000ppm	5.12	5.45	5.28
Ethephon @ 250ppm	5.38	5.82	5.60
Ethephon @ 500ppm	5.12	5.67	5.39
Ethephon @ 1000ppm	5.06	5.60	5.33
Mean	4.90	5.32	

CD at 5%

Treatment (T)	0.22
Genotype (G)	0.91
Treatment x Genotype (TxG)	NS

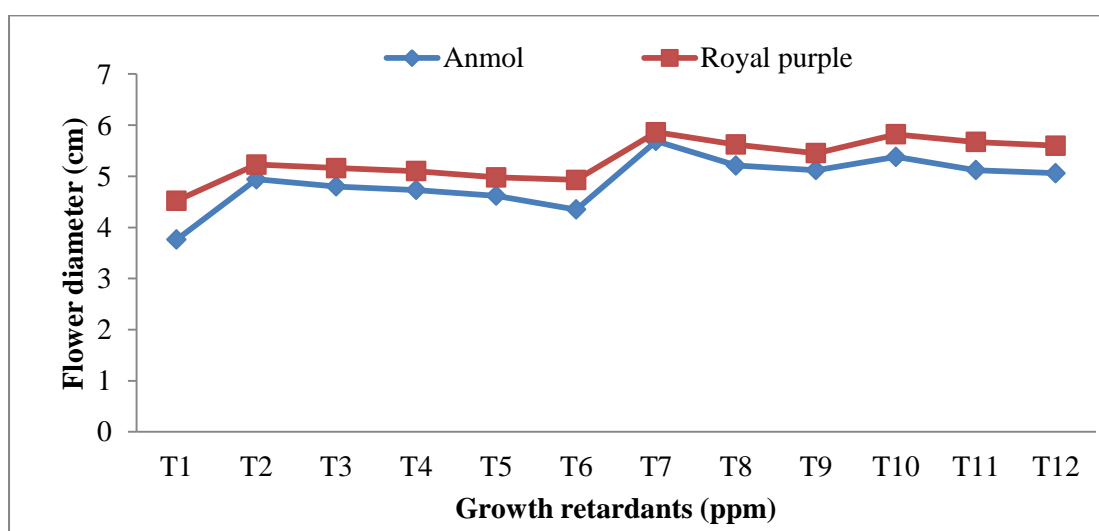


Fig. 4.2.4: Effect of growth retardants on flower diameter (cm) in chrysanthemum cvs. Anmol and Royal Purple

T ₁ : Control	T ₂ : CCC @ 500ppm	T ₃ : CCC @ 750ppm
T ₄ : CCC @ 1000ppm	T ₅ : CCC @ 1250ppm	T ₆ : CCC @ 1500ppm
T ₇ : Daminozide @ 500ppm	T ₈ : Daminozide @ 750ppm	T ₉ : Daminozide @ 1000ppm
T ₁₀ : Ethephon @ 250ppm	T ₁₁ : Ethephon @ 500ppm	T ₁₂ : Ethephon @ 1000ppm



**Plate 8: Number of flowers per plant in cv. Anmol
(a) Control (b) Daminozide @ 1000 ppm**



**Plate 9: Number of flowers per plant in cv. Royal Purple
(a) Control (b) Daminozide @ 1000 ppm**

The effect of growth retardants on flower diameter is in close conformity with the findings of Naidu *et al* (2014), Asrar *et al* (2014), when growth retardant Alar (daminozide) @ 1500 ppm was applied as a foliar spray on chrysanthemum. By the applications of growth retardants, metabolic changes takes place in the cells. Metabolites are accumulated or conserved in the flowers as the flowers act as a reservoir for metabolites which resulted in increased flower size.

4.2.5 Number of flowers/plant

The number of flowers/plant was significantly affected with different concentrations of growth retardants as depicted in Table 4.2.5 and Fig. 4.2.5. Among different growth retardants treatments tried, the maximum (28.81) number of flowers/plant was obtained in daminozide @ 1000 ppm, followed by treatment comprising ethephon @ 1000 ppm showing 28.01 number of flowers/plant. The minimum number of flowers/plant (21.36) was obtained in treatment comprising CCC @ 1500 ppm with second lowest (21.56) number of flowers/plant was found in CCC @ 1250 ppm. All these treatments differed significantly with each other with respect to number of flowers/plant.

Table 4.2.5 Effect of growth retardants on number of flowers/ plant in chrysanthemum cvs. Anmol and Royal Purple

Treatments	Varieties		Mean
	Anmol	Royal Purple	
Control	25.86	21.30	23.58
CCC @ 500ppm	25.20	21.23	23.21
CCC @ 750ppm	25.03	20.63	22.83
CCC @ 1000ppm	24.16	19.70	21.93
CCC @ 1250ppm	23.80	19.33	21.56
CCC @ 1500ppm	23.50	19.23	21.36
Daminozide @ 500ppm	27.60	24.78	26.19
Daminozide @ 750ppm	28.40	25.80	27.1
Daminozide @ 1000ppm	31.06	26.56	28.81
Ethephon @ 250ppm	28.63	24.61	26.62
Ethephon @ 500ppm	29.50	25.92	27.71
Ethephon @ 1000ppm	30.00	26.02	28.01
Mean	26.89	22.92	

CD at 5%

Treatment (T)	0.76
Genotype (G)	0.31
Treatment x Genotype (TxG)	NS

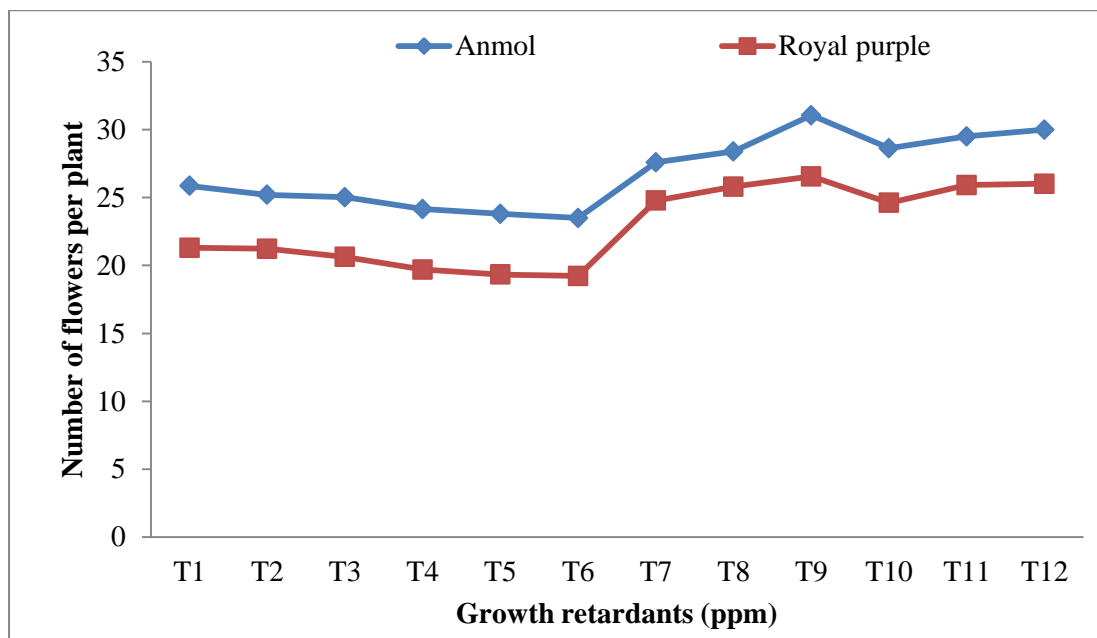


Fig. 4.2.5: Effect of growth retardants on number of flowers/ plant in chrysanthemum cvs. Anmol and Royal Purple

T₁ : Control	T₂ : CCC @ 500ppm	T₃ : CCC @ 750ppm
T₄ : CCC @ 1000ppm	T₅ : CCC @ 1250ppm	T₆ : CCC @ 1500ppm
T₇ : Daminozide @ 500ppm	T₈ : Daminozide @ 750ppm	T₉ : Daminozide @ 1000ppm
T₁₀ : Ethephon @ 250ppm	T₁₁ : Ethephon @ 500ppm	T₁₂ : Ethephon @ 1000ppm

Irrespective of the treatments, the two genotypes Anmol and Royal Purple also differed significantly. The maximum number of flowers/plant (26.89) was recorded in cv. Anmol, as compared to (22.92) number of flowers/plant in cv. Royal Purple. The interaction effect of two factors was found non-significant. In cv. Anmol maximum number of flowers/plant (31.06) was found in treatment comprising daminozide @ 1000 ppm while minimum number of flowers/plant (23.50) was obtained in treatment comprising CCC @ 1500 ppm with second lowest (23.80) number of flowers/plant was found in CCC @ 1250 ppm (Plate 7). Similarly in cv. Royal Purple maximum number of flowers/plant (26.56) and minimum number of flowers/plant (19.23) was recorded in same treatments as that of cv. Anmol (Plate 8).

Similar to our findings results have been reported by Naidu *et al* (2014), Patil *et al* (2014) and Kazaz *et al* (2010), when growth retardant Alar (daminozide) @ 3000mg/L was applied as a foliar spray on chrysanthemum. Increase of number of flowers per plant might be due to increase in plant spread in terms of both N-S and E-W.

4.2.6 Duration of flowering (days)

The perusal of data depicted in Table 4.2.6 and Fig. 4.2.6 reveals that the duration of flowering was significantly affected with different concentrations of growth retardants. Among

different growth retardants treatments tried, the maximum (22.63 days) duration of flowering was obtained in daminozide @ 1000 ppm, followed by treatment comprising CCC @ 1000 ppm showing 21.75 days duration of flowering. The minimum duration of flowering (18.26 days) was obtained in treatment comprising ethephon @ 1000 ppm with second lowest (18.48 days) duration of flowering was found in ethephon @ 500 ppm. All these treatments differed significantly with each other with respect to duration of flowering.

Irrespective of the treatments, the two genotypes Anmol and Royal Purple also differed significantly. The maximum duration of flowering (21.34 days) was recorded in cv. Anmol, as compared to (18.86 days) duration of flowering in cv. Royal Purple. The interaction effect of two factors was found significant. In cv. Anmol maximum duration of flowering (25.06 days) was found in treatment comprising daminozide @ 1000 ppm while minimum duration of flowering (19.16 days) was obtained in treatment comprising ethephon @ 1000 ppm with second lowest (19.46 days) duration of flowering was found in ethephon @ 500 ppm. Similarly in cv. Royal Purple maximum duration of flowering (20.20 days) and minimum duration of flowering (17.36 days) was recorded in same treatments as that of cv. Anmol.

Table 4.2.6: Effect of growth retardants on duration of flowering (days) in chrysanthemum cvs. Anmol and Royal Purple

Treatments	Varieties		Mean
	Anmol	Royal Purple	
Control	20.56	18.73	19.65
CCC @ 500ppm	20.06	18.76	19.41
CCC @ 750ppm	20.46	18.80	19.63
CCC @ 1000ppm	23.66	19.83	21.75
CCC @ 1250ppm	21.13	19.70	20.41
CCC @ 1500ppm	21.16	19.80	20.48
Daminozide @ 500ppm	22.63	18.86	20.75
Daminozide @ 750ppm	23.09	19.16	21.12
Daminozide @ 1000ppm	25.06	20.20	22.63
Ethephon @ 250ppm	19.70	17.63	18.66
Ethephon @ 500ppm	19.46	17.50	18.48
Ethephon @ 1000ppm	19.16	17.36	18.26
Mean	21.34	18.86	
CD at 5%			
Treatment (T)		0.53	
Genotype (G)		0.21	
Treatment x Genotype (TxG)		0.75	

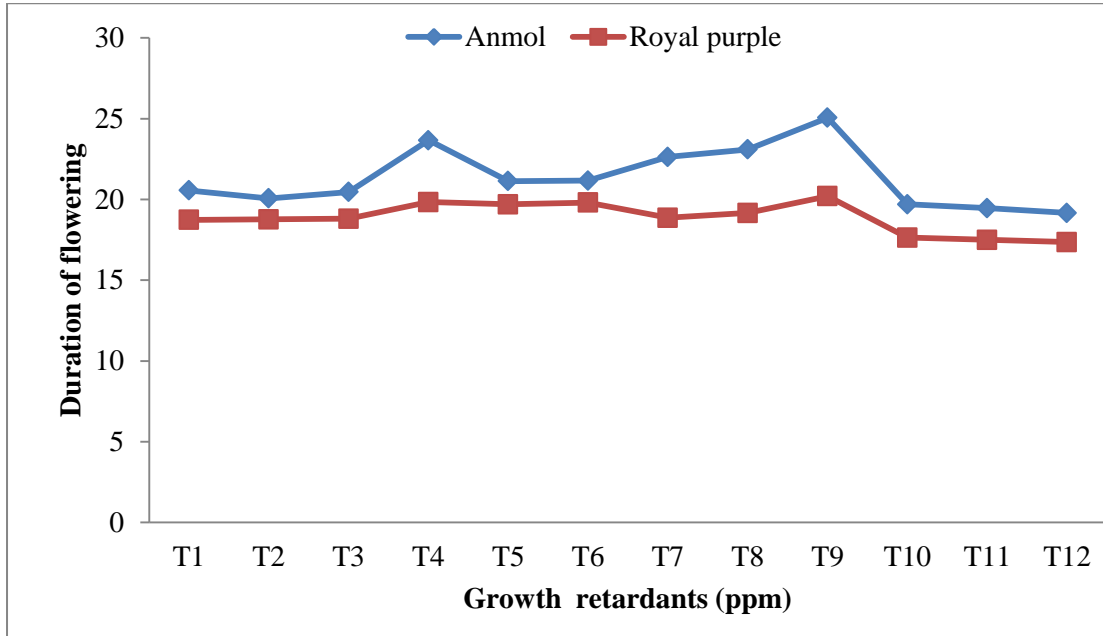


Fig. 4.2.6: Effect of growth retardants on duration of flowering (days) in chrysanthemum cvs. Anmol and Royal Purple

T₁ : Control	T₂ : CCC @ 500ppm	T₃ : CCC @ 750ppm
T₄ : CCC @ 1000ppm	T₅ : CCC @ 1250ppm	T₆ : CCC @ 1500ppm
T₇ : Daminozide @ 500ppm	T₈ : Daminozide @ 750ppm	T₉ : Daminozide @ 1000ppm
T₁₀ : Ethephon @ 250ppm	T₁₁ : Ethephon @ 500ppm	T₁₂ : Ethephon @ 1000ppm

The increased duration of flowering in daminozide are in close conformity with the findings of Asrar *et al* (2014) who also reported increased duration of flowering with increasing concentration of Alar (daminozide) @ 1500, 3000, 4500 ppm. The decreased duration of flowering as in case of other retardants might be due to increased respiration which leads to senescence at higher concentration (Abeles 1973).

CHAPTER V

SUMMARY

The present investigations entitled “Effect of growth retardants on growth and flowering of Chrysanthemum (*Chrysanthemum morifolium* Ramat.)” were carried out at the Research Farm, Department of Floriculture and Landscaping, Punjab Agricultural University, Ludhiana, during the year 2015-16. The study was carried out to standardize the optimum concentrations of different growth retardants for alteration of plant architecture and improvement of flowering parameters in chrysanthemum.

Chrysanthemum (*Chrysanthemum morifolium* Ramat.) is one of the most widely cultivated herbaceous perennial plant belongs to family ‘Asteraceae’ and commonly known as “Autumn Queen” or “Queen of East” and reported to be native of northern hemisphere, mainly Europe and Asia. It ranks next to rose in the international market due to wide variation with respect to its growth habit, flower colour, shape and size of flowers, long lasting floret life and diversity in height. It ranks 2nd among cut flowers and 4th among the potted plants around the globe.

The experiment consisted of two chrysanthemum varieties Anmol and Royal purple. Anmol is a late flowering variety, flowers are bright yellow, anemone type and highly suitable for pot culture while Royal purple is a late flowering variety, flowers are purplish pink, anemone type and highly suitable for pot culture. The rooted cuttings of both the varieties were transplanted in the 1st week of August in pots and different concentrations of growth retardants were applied after first pinching 30 days after transplanting and another two applications were applied at 15 days interval to study the optimum concentration of growth retardants for commercial applications in chrysanthemum. Control plants were sprayed with distilled water. The experiment was conducted in Factorial completely randomized design (FCRD) with three replications comprising ten pots per replication.

The observations were recorded on vegetative and flowering characteristics. Vegetative characters include plant height, internodal length, diameter of main stem at flowering, plant spread, leaf area, leaf colour, flower characters include days to bud appearance, days to colour break stage, days to full bloom stage, flower diameter, number of flowers/plant and duration of flowering. The results and discussion of the experiment were tabulated in chapter IV and are summarized here as follows:

5.1 Effect of different growth retardants on plant architecture of chrysanthemum

There was significant reduction in plant height with increasing concentrations of growth retardants. Minimum plant height (24.13 cm) at first bud appearance and internodal

length (3.20 cm) was recorded in cv. Anmol with treatment daminozide @ 1000 ppm. Similarly in cv. Royal Purple plant height (22.29 cm) and internodal length (3.48 cm) was found minimum at same concentration as that of cv. Anmol. Plant height (27.09 cm), (25.24 cm) and internodal length (5.12 cm), (5.21 cm) was recorded maximum in control plants of Anmol and Royal Purple respectively.

Diameter of main stem (5.90 mm), plant spread (15.36 cm) and leaf area (2.66) was found maximum in cv. Anmol with treatment daminozide @ 1000 ppm while diameter of main stem (4.01 mm), plant spread (13.07cm) and leaf area (1.03) was found minimum in control. Similarly in cv. Royal Purple maximum diameter (5.97 mm), plant spread (18.40 cm) and leaf area (1.93) was recorded in daminozide @ 1000 ppm while minimum diameter (4.07 mm), plant spread (14.80 cm) and leaf area (0.53) was recorded in control.

On the basis of visual observations, leaf colour was noticed i.e dark green, green, light green in comparison to normal plant. In all the treatments where CCC (cycocel), daminozide and ethephon were sprayed leaves were dark green as compared to control.

5.2 Effect of different growth retardants on flowering parameters of chrysanthemum

Minimum number of days to bud appearance (80.56 days), colour break stage (103.66 days) and full bloom stage (123.56 days) in cv. Anmol was recorded in daminozide @ 1000 ppm while maximum days to bud appearance (86.06 days), colour break stage (107.73 days) and full bloom stage (128.73 days) was found in ethephon @ 1000 ppm. Similarly in cv. Royal Purple minimum number of days to bud appearance (83.76 days), colour break stage (105.76 days) and full bloom stage (125.26 days) was recorded in daminozide @ 1000 ppm while maximum days to bud appearance (88.53 days), colour break stage (109.33 days) and full bloom stage (131.23 days) was recorded in ethephon @ 1000 ppm.

The maximum flower diameter (5.69 cm) and (5.86 cm) was recorded in daminozide @ 500 ppm in both cvs. Anmol and Royal Purple respectively while minimum (3.76 cm) and (4.52 cm) was found in control plants of Anmol and Royal Purple respectively. Maximum number of flowers/plant (31.06) and (26.56) was recorded in daminozide @ 1000 ppm in both cvs. Anmol and Royal Purple respectively while minimum (23.50) and (19.23) was recorded in CCC @ 1500 ppm in both cvs. Anmol and Royal Purple respectively. Maximum duration of flowering (25.06 days) in cv. Anmol was recorded in daminozide @ 1000 ppm while minimum (19.16 days) was recorded in ethephon @ 1000 ppm. Similarly in cv. Royal Purple maximum duration of flowering (20.20 days) was found in daminozide @ 1000 ppm while minimum (17.36 days) was recorded in ethephon @ 1000 ppm.

On the basis of research findings of this investigation, it can be concluded that daminozide @ 1000 ppm and ethephon @ 1000 ppm concentration was found to be the

effective in creating dwarfness in both the cultivars. Number of flowers/plant, duration of flowering and plant spread was also recorded maximum at 1000 ppm of daminozide in both the cultivars Anmol and Royal Purple. Thus, from the present studies, it can be concluded that daminozide @ 1000 ppm concentration is the effective concentration in chrysanthemum.

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