EFFECT OF GIBBERELLIC ACID AND CERTAIN OTHER CHEMICALS ON THE CUT FLOWER PRODUCTION OF CHRYSANTHEMUM (*Dendranthema grandiflora* Tzelev.) CULTIVARS

Thesis submitted in part fulfillment of the requirements for the degree of

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2000

CERTIFICATE

This is to certify that the thesis entitled ***"EFFECT OF GIBBERELLIC ACID AND CERTAIN OTHER CHEMICALS ON THE CUT FLOWER PRODUCTION OF CHRYSANTHEMUM (Dendranthema grandiflora Tzelev.) CULTIVARS "*** *submitted in part fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE (HORTICULTURE)*** *to the* ***TAMIL NADU AGRICULTURAL UNIVERSITY, COIMBATORE*** *is a record of* ***bonafide*** *research work carried out by* ***Miss. S.PADMA PRIYA*** *under my supervision and guidance and that no part of this thesis has been submitted for the award of any degree, diploma, fellowship or other similar titles or prizes and that the work has not been published in part or full in any scientific or popular journal or magazine.*

Place: Coimbatore
Date : 19.7.2000

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(S.PADMA PRIYA)

Abstract

ABSTRACT

EFFECT OF GIBBERELLIC ACID AND CERTAIN OTHER CHEMICALS ON THE CUT FLOWER PRODUCTION OF CHRYSANTHEMUM (*Dendranthema grandiflora* Tzelev.) CULTIVARS

By

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An investigation was undertaken to study the effect of exogenously applied Gibberellic acid and certain other chemicals on the cut flower production of four cultivars of Chrysanthemum. The growth substances used were Gibberellic acid (GA_3 100 and 150 ppm), Salicylic acid (SA 50 and 100 ppm), Triacontanol (TR 1, 2 and 3 ppm), and Brassinolide (BR 0.1, 0.2 and 0.3 ppm). The growth substances were applied as foliar sprays at three stages *viz.*, 30, 45 and 60 days after transplanting with water spray as control. The selected cut flower cultivars include Baggi, Indira, Red Gold and Shymal.

The morphological characters such as height of the plant and number of branches were found to increase drastically on application of GA_3. The cultivar Shymal exhibited the highest height of the plant (67.88 cm) and Red Gold with the largest branch number of 15.75 on combination with GA_3 150 ppm.

The application of GA_3 150 ppm also recorded an early flowering in the cultivars Indira and Red Gold. A longest duration of flowering (76.50 days) was registered in Red Gold with GA_3 100 ppm. The length of the flower stalk and spray was significantly improved by GA_3 application compared to other chemicals in all the four cultivars. A pronounced increase in length of the stalk (35.91 cm) was obtained in Indira at GA_3 150 ppm. The highest flower diameter (7.88 cm) was noticed in Indira on treatment with BR 0.2 ppm.

The number of flowers per plant was the highest (139.10) in Red Gold with TR 3 ppm. SA at 50 ppm increased the weight of 100 flowers (404.85 g) in Shymal, whereas SA at 100 ppm enhanced the flower yield per plant (370.65 g) and calculated yield per hectare (41182.74 kg) in Red Gold.

Leaf chlorophyll 'a', chlorophyll 'b' and total chlorophyll at vegetative stage were significantly raised by application of BR at 0.3 ppm in Baggi (1.416, 0.511 and 1.582 mg/g respectively). The unoxidized IAA in Indira was increased from pre-flowering stage (3032.72 µg/g/h) to

peak-flowering stage (3265.18 µg/g/h) due to GA_3 150 ppm, the total phenol content was the highest (26.425 mg/g) in Baggi on combination with SA 100 ppm.

Correlation studies indicated that the yield had significant positive correlation with number of branches (0.577), duration of flowering (0.572) and number of flowers per plant (0.854).

Pre-harvest spray of SA at 100 ppm in combination with silver nitrate (0.2%) and sucrose (2.0%) enhanced vase life of Indira upto 18.4 days.

The sprays of Triacontanol at 3 ppm gave an increased gross income (Rs.2,20,000) and net income (Rs.1,66,260) per hectare with a cost of production of 50,000 per hectare. The cost benefit ratio was estimated as 1:4.09.

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ABBREVIATIONS

GA_3	-	Gibberellic acid
SA	-	Salicylic acid
TR	-	Triacontanol
BR	-	Brassinolide
NAA	-	Naphthalene acetic acid
BA	-	Benzyl adenine
IAA	-	Indole acetic acid
1ACC	-	1– Amino cyclopropane carboxylic acid
$AgNo_3$	-	Silver nitrate
$Al_2(SO_4)_3$	-	Aluminium sulphate
STS	-	Silver thiosulphate
BAP	-	Benzyl amino purine

Introduction

Chapter 1

INTRODUCTION

Chrysanthemum (Chrysos-golden ; anthos-flower) is a popular flower crop of commercial importance. In many countries including the United States and Japan it is considered as number one, maintaining its eminent position over the years, known as the 'Queen of East'. Chrysanthemum has its admirers and enthusiasts all over the world. The spray Chrysanthemums, which are the basic ingredient of the mixed bunch, have the major share of all the Chrysanthemums sold throughout the world. Its demand is likely to increase with more and more cut flowers now being sold through flower markets. Chrysanthemums are the favourites of florists due to their long vase life and exceptionally hardy nature. Growers like it due to their relatively easy to grow nature for year round production as compared to most of the other flowers and for being less prone to pests and diseases.

The world trade in floriculture products is estimated to be worth nearly US$ 6.9 billion and the demand is estimated at US$ 50 billion (Dadlani, 1997). The flower consumption is projected to increase steadily over the coming years. Floriculture in India is no longer the domain of the corporate lords. Slowly and steadily small farmers are also entering into the business. The boom period in the floriculture industry last year

is encouraging many more to switch on to the venture. And as a result, floriculture has in the recent years emerged as a viable diversification option in agribusiness, in the country. The cut flowers have the biggest involvement in import export trade in the world.

The commonly grown cultivars of Chrysanthemum produce medium sized flowers with short and thick stalks. While large compact flowers with straight stalks are considered ideal for cut flower industry. Though the quality is primarily a varietal trait, it could also be influenced and altered by the application of growth regulating chemicals.

As on date, studies are encouraged only towards the production of cut flowers under protected conditions. So far only meagre attempts are made for production of a crop with cut flower standard under field conditions. So, an attempt has been made to select varieties of Chrysanthemum suitable for cut flower production by subjecting to chemical regulation. In addition, whenever the cut flower is not produced upto to the specified standards, the flowers could also be effectively put into use for loose flower trade. The study is carried out as a field trail to meet the demands of local markets with following objectives.

1. To evaluate the best genotype / cultivar suitable for cut flower production of Chrysanthemum.

2. To study the effect of Gibberellic acid and certain other chemicals on growth pattern and flowering on cut flower production of Chrysanthemum.

3. To optimise the concentration of growth promoting chemicals suitable for stem elongation for cut flower production.

4. To study the effect of Gibberellic acid and certain other chemicals on vase life, physiochemical parameters and cost economics in Chrysanthemum for maximising the profits.

Review of Literature

Chapter 2

REVIEW OF LITERATURE

Perfection in the form of plant, the quality of flowers and increase in flower production are the growers main objectives in the flower and ornamental crop culture. Various chemicals are currently being tried for controlling the growth and flowering of ornamentals. It is being done either to retard or stretch-out the plant growth as desired. Growth regulators are known to modify growth and development of the plant including flowering at optimum concentrations. Exogenously applied growth substances alters the levels of endogenous hormones thus modifying the growth and development of plants.

In India, commercial production of cut flowers has registered a steady increase in the recent past. On this score, the potential of Chrysanthemum as a cut flower is being enhanced through chemical regulation. The main emphasis is laid on the improvement of the crop through stem elongation. In this chapter, attempts are made to review the work done on Chrysanthemum and other flower crops with growth regulating substance like Gibberellic acid and certain other related chemicals.

2.1. Effect of Gibberellic acid and certain other chemicals on morphological characters

2.1.1. Height of the plant

The application of growth substances is characterized by an increase or decrease in plant height as a result of stem elongation or its suppression. Generally, spraying of Gibberellic acid (GA_3) brings about a significant effect on elongation of the stem. It has been evidenced in a number of flower crops as reported by many workers.

Mastalerz (1960) affirmed that the application of GA_3 at 100 ppm resulted in marked increase in stem length in various flower crops like Roses, Dwarf dahlias, and Snap dragons.

A comprehensive study on the effect of GA_3 on the growth of Chrysanthemum was conducted by Moore (1966). It was observed that treatment of GA_3 at 200 ppm resulted in better regulation of top and root growth.

Mittal (1967) found that in Dahlia, the application of GA_3 at 50, 100, 250, 300 and 500 ppm, twice before anthesis significantly increased the plant height. The increase in height was directly proportional to the concentration of GA_3 upto 300 ppm. However, higher concentration of 500 ppm was found to be inhibitory.

Sen and Maharana (1972) observed in Chrysanthemum that GA_3 spray in general, caused hyper elongation of stem and internodes and also increased the leaf area and petiole length. Shanmugam *et al.* (1973) furnished that GA_3 significantly increased the stem length in Chrysanthemum when sprayed thrice at 30, 45 and 60 days after planting at 100, 200 and 400 ppm concentrations.

Chrysanthemum morifolium cv. Canova when given six sprays of 12.5, 25.0 or 50.0 ppm of GA_3 at monthly intervals in two successive seasons resulted in longer stems in first season but stunting in the second season (Shoushan *et al.*, 1973). Reddy (1977) affirmed that in China aster, treatment with GA_3 at 200 ppm showed increased plant height.

Oxeye daisies (*Chrysanthemum leucanthemum*) when treated with 50 or 100 ppm of GA_3 exhibited tallest plants with increased stem length (Castro *et al.*, 1979). Menhenett (1979) found that the application of a single dose of 20 or 40 µg GA_3 exhibited higher stem extension in *Chrysanthemum morifolium* cv. Bright Golden Anne.

The influence of GA_3 (1000 ppm) was investigated under inductive short-day (8 hr) and non-inductive long-day (16 hr) conditions in Chrysanthemum cv. Aste Lee. It resulted in increased stem elongation in non-vernalized plants (Zimmer and Bahnemann, 1980).

Dahab *et al.* (1987) reported an increase in plant height when Chrysanthemum plants were sprayed with GA_3 at 500 and 1000 ppm. Nagarjuna *et al.* (1988) opined that plant height in *Chrysanthemum indicum* at the time of harvest was the highest (60.3cm) when treated with GA_3 at 200 ppm.

The inhibition by uniconozole is reversed by an exogenous application of Brassinolide (BR). Based upon the time course of change in responsiveness by isolated Zinnia mesophyll cells, a hypothesis is proposed that BR act as a endogenous controlling factor during the process of induction of tracheal element (TE) differentiation (Toshisuke Iwasaki and Hiroh, Shibaoka, 1991).

Holcomb *et al.* (1991) observed in Chrysanthemum that foliar spray of 200 mg GA_3 per litre increased the plant height. Talukdar and Paswan (1994) demonstrated that the tallest plants were produced in Chrysanthemum cv. Turmuli when GA_3 was applied at 200 ppm concentration.

Verma *et al.* (1997) indicated that periodic sprays of Chrysanthemum cv. Cotton Ball with GA_3 100 ppm alone enhanced the length of the stem. With combination of 100 ppm ascorbic acid it displayed synergistic effect by further enhancement of stem elongation.

Triacontanol (TR) applied at 0.001, 0.01 and 0.1 mg per litre to seeds of *Zinnia elegans* cv. Illumination, at lowest concentration

increased seedling growth (Blamowski and Borowski, 1995). Pot experiment with Chrysanthemum cv. Prof. Harris sprayed with GA_3 at 10, 20 or 40 ppm significantly increased the plant height, with 40 ppm being most effective (Talukdar and Paswan, 1996).

Kulkarni *et al.* (1997) reported that Chrysanthemum cv. Karnool treated with 50, 100 and 200 ppm GA_3 showed increased pattern of stem length with the highest at 100 ppm followed by BR at 0.30 ppm. Dutta and Seemanthini (1997) observed a higher plant height (67.4 cm) from the treatment of GA_3 at 150 ppm in *Dendranthema grandiflorum.*

Chrysanthemum cv. Snow Ball, Kiku Biori, Grape Bowl and Lilac sprayed with 10, 20 or 40 ppm GA_3, 35 days after planting resulted in the greatest plant height with an average of 65.30 cm (Talukdar and Paswan, 1998).

Zalewska (1998) reported that among the pot Chrysanthemums cv. Cassablanca white, Gandes, Piecas, Pink Elani, Orange Elani Veria and Veria Roze trained as standard with GA_3 (500 mg/l) at weekly intervals. GA_3 lengthened the stem by 19.5 – 22.2 per cent in all cultivars except Veria Roze.

Cut flower Chrysanthemum cv. Ha-Lei and Chin-Sin-Hwang sprayed with 20 ppm of GA_3 resulted in increased stem length by 3.0 – 5.0 cm (Sheu-Chian Shinn *et al.,* 1998). Ramesh (1999) concluded that GA_3 at all levels (100, 150 and 200 ppm) maintained a higher plant

height. A dose of 150 ppm recorded best results of 65.40 cm in China aster.

2.1.2. Effect on length of internode, number of suckers and branches

Increased length of branches and height of the stem were obtained by spray of GA_3 at 0.01 per cent in China aster, Marigold, Zinnia and Stock (Tamberg, 1963). Mittal (1967) observed in Dahlia that on treatment with GA_3 an increased internodal length and enhanced production of axillary branches especially at lower nodes occured.

In Chrysanthemum cv. Early Yellow, GA_3 at 50, 100, 150 and 200 ppm increased the number of nodes and branches (Sen and Maharana, 1972). Suckers of Chrysanthemum cv. Otome Zakura which were chilled for about 0-40 days and later sprayed with GA_3 at 100 ppm resulted in accelerated elongation of internode (Kher *et al.*, 1972).

Shanmugam *et al.* (1973) reported that application of GA_3 at 100, 200 and 400 ppm consistently increased the internodal length in Chrysanthemum. The effect being more pronounced at 400 ppm concentration.

In China aster, an increased internodal length was obtained with GA_3 at a concentration of 300 ppm. In the same investigation, it was observed that GA_3 at 100 ppm increased the number of branches of China aster (Reddy, 1983).

Interactions between diaminozide and a subsequent application (1 or 10 m µg) of GA_3, GA_9 or GA_{20} on stem extension in Chrysanthemum cv. Bright Golden Anne indicated that in the absence of diaminozide, GA_3 was very active in promoting internode extension soon after their application (Menhenett, 1979).

Two cultivars of *Chrysanthemum morifolium* 'Golden Horim' and 'Golden Miqual' when cultivated in nutrient solution containing TR, the dry weight of shoot and whole plant was increased (Skogen *et al.*, 1983). GA_3 at 500 and 1000 ppm increased the number of shoots per plant and length of shoots in Chrysanthemum (Dahab *et al.*, 1987).

Chrysanthemum indicum plants expressed supremacy of GA_3 accounting for 100 per cent (63.43) extra primary branches over control. Total number of branches was also increased with GA_3 treatment, (216.56 – 229.70). Moreover, GA_3 at 200 ppm recorded higher number of suckers (Nagarjuna *et al.*, 1988).

Mukopadhya (1990) opined that spraying of GA_3 at 100 ppm promoted plant growth and lateral branching in Carnation cv. Improved Margurite. An increase in number of leaves and branches were observed in China aster when plants were sprayed with GA_3 at 200 ppm (Syamal *et al.*, 1990).

Dutta and Seemanthini (1997) noticed that in Chrysanthemum the internodal length was increased by NAA and GA_3 application. GA_3 at

150 ppm recorded the largest internode (7.50 cm) and more number of nodes (202.00).

Chrysanthemum morifolium cv. Karnool treated with GA_3 at 100 ppm recorded the highest number of primary (5.87) and secondary branches (12.50) followed by BR at 0.5 mg/l coupled with pinching (Kulkarni *et al.*, 1997).

In China aster cv. Kamini the length of the branch and internodal length was considerably increased by GA_3 application especially at 150 ppm. Further GA_3 at 200 ppm showed lowest number of branches (Ramesh, 1999).

2.2. Effect of Gibberellic acid and certain other chemicals on floral characters

2.2.1. Effect on the number of days taken for first flowering and flowering duration

Amongst the plant hormones, Gibberellins are known to replace the photoperiod and low temperature requirement for flowering in large number of plants (Lang, 1965). According to Mathuhin and Maksimova (1960) Chrysanthemum grown under natural day length produced earlier flowering by treatment with GA_3 (0.2%).

Flowering in China aster was accelerated by 15-16 days with GA_3 sprays (Tamberg, 1963; Reddy, 1977). Sen and Maharana (1972) treated potted Chrysanthemums with GA_3 at 50, 100 or 200 ppm, found that

flowering was advanced by about 13 days by GA_3 at 50 ppm and by 6 days at 100 ppm.

In China aster, earlier flowering was obtained with GA_3 at concentrations of 100, 200 and 300 ppm. The longest duration of flowering was recorded by GA_3 at 300 ppm (Reddy and Sulladmath, 1972). Suckers of Chrysanthemum cv. Otome Zakura treated with 100 ppm of GA_3 after a chilling period of 30 days produced early flowering (Kher *et al.*, 1972).

Pharis (1972) observed that in Chrysanthemum cultivar Pink Champagne, the effects of GA_3 and BA were synergistic and the concentration of either growth substance was a limiting factor with regard to number of plants flowering under long days.

Application of Salicylic acid (SA) at 1.0 and 100 ppm concentration in *Impatiens balsamina* caused early induction of flowering (Nanda *et al.*, 1976). Stoutmeyer (1982) opined that treatment with TR increased the growth and production of flowers in the orchid *Cymbidium* spp.

Dendrobium seedlings sprayed three times with 0.1 g of TR per square feet flowered earliest (18 months after spraying) followed by plants sprayed once with 0.01 mg per square feet. Plants sprayed four time with 0.01 or 0.05 mg per square feet flowered 21 months after spraying. While unsprayed ones did not bloom (Yee, 1983).

Two cultivars of *Chrysanthemum morifolium* 'Golden Horim' and 'Golden Miquel' treated with TR resulted in bud breaking and flowering a week earlier when compared to that of control (Skogen *et al.*, 1983).

Das *et al.* (1984) reported early initiation of flowering in Marigold when sprayed with GA_3 at 100 ppm. Dahab *et al.* (1987) affirmed that *Chrysanthemum fruitescens* treated with GA_3 (250, 500 and 1000 ppm) accelerated the flowering. However, it decreased the number of inflorescence per plant.

Jayanthi and Gowda (1991) affirmed that in China aster, spraying of GA_3 at 250 ppm caused early flowering. The stimulatory effect of SA in flowering was demonstrated in species of Lemnaceae, *Oncidium* and *Impatiens balsamina* (Raskin, 1992). Dutta and Seemanthini (1997) demonstrated that sprays of GA_3 at 50 ppm increased the duration of flowering in Chrysanthemum cv. Co.1. Talukdar and Paswan (1998) furnished that in Chrysanthemum application of 10, 20 or 40 ppm of GA_3 induced early flowering.

2.2.2. Effect on flower diameter and length of flower stalk

Lert (1959) studied the effect of Gibberellin in Chrysanthemum and concluded that GA_3 treatments from 10 to 50 ppm significantly increased length of flower stalk and diameter of the flower under short-day conditions.

Reddy and Sulladmath (1972) observed that in China aster, GA_3 at all concentrations (100, 200 and 300 ppm) increased the peduncle length and reduced the thickness of flower compared to control. In *Chrysanthemum morifolium* cv. Canova sprayed with IBA and GA_3 at 50 and 25 ppm increased the flower diameter (Shoushan, 1973).

El-Shafie and Hassan (1978) opined that in Gerbera, GA_3 treatment increased the flower diameter and peduncle length. Shanmugam and Muthusamy (1982) observed that a higher flower diameter (5.92 to 5.99 cm) with GA_3 spray of 200 ppm followed by 100 ppm in Chrysanthemum.

Kofranek and Cockshull (1985) concluded that in pompon type Chrysanthemum cv. Flame Belair, Hurricane and Statesman sprayed with GA_3 at 20 ppm on the apical region resulted in elongation of peduncles without inflorescence abnormalities or delay in flowering.

Nagarjuna *et al.* (1988) reported that Chrysanthemum sprayed with GA_3 at 200 ppm gave larger flowers (5.92 – 5.99 cm diameter) followed by GA_3 100 ppm (5.85 to 5.89 cm). Kuriesh *et al.* (1989) observed a reduction in flower weight in Chrysanthemum with foliar sprays of GA_3 at 100 ppm. Holcomb *et al.* (1991) found in Chrysanthemum that foliar spray of 20 mg/l of GA_3 increased the peduncle length.

Field grown potted plants of *Campanula carpatica* cv. Karl Fooster and Blue Clips treated with SA at 0, 100, 500 or 1000 μ mol per litre and kept in controlled environment. Treatment with 100 μ mol per litre of SA increased the flower size enhancing the decorative value (Serek, 1992).

Cotton Ball, Ajay and Vijay are dwarf flower cultivars of Chrysanthemum, when treated with GA_3 showed pronounced effect of increased length of spray by 10.5 cm over control in Cotton ball (Verma *et al.*, 1997).

Kulkarni *et al.*, (1997) observed that Chrysanthemum cv. Karnool sprayed with GA_3 100 ppm along with pinching resulted in larger flower diameter (6.25 cm) followed by 0.5 ml per litre of BR (4.53 cm).

Sheu Chian Shinn et al., (1998) affirmed that Chrysanthemum cv. La-Lei exhibited enlarged flower diameter by 10 per cent with GA_3 treatment. Stem and peduncle lengths were increased by GA_3 treatments between 20 and 80 ppm.

In China aster cv. Kamini application of BR at 0.25 ppm increased the flower diameter and BR at 0.50 ppm produced highest individual flower weight. GA_3 at 150 ppm recorded an increased length of the flower stalk (Ramesh, 1999).

2.2.3. Effect on number and yield of flowers

Sen and Maharana (1972) opined that GA_3 treatment at

concentrations of 50, 100 or 200 ppm increased the flower size as well as the number of flowers in Chrysanthemum.

Shanmugam *et al.* (1973) observed in Chrysanthemum that GA_3 at 100 ppm registered the highest yield in flowers with an increase of 14.7 and 12.0 number of flowers over control in white and yellow varieties respectively.

El-Shafie and Hassan (1978) opined that in Gerbera lower concentration of GA_3 enhanced the number of flowers at 100 ppm during the first season. In China aster total number of flowers per plant were increased with increase in GA_3 concentration and 200 ppm was found to be optimum (Reddy, 1983).

The number of floral buds and flowers per plant were increased in plants receiving a single treatment with combination of GA_3 and SA accompanying a single short-day cycle in *Impatiens balsamina* (Vini Sood and Nanda, 1979).

Skogen *et al.* (1983) found that in *Chrysanthemum morifolium* cv. Golden Horim and Golden Miquel the number of inflorescence per plant and number of flowers per inflorescence increased as a response to TR treatment.

Luda *et al.* (1985) obtained an increased number of flowers in Gerbera on application with 100 ppm of GA_3. Nagarjuna *et al.* (1988)

opined that in Chrysanthemum, treatment with GA_3 recorded the increased weight of flowers (110.00 – 113.33 g/plant).

Syamal *et al.* (1990) recorded higher number of flowers in Marigold and China aster with foliar spray of GA_3 at 200 ppm. Singh *et al.* (1991) noted that 500 ppm of GA_3 increased flower yield, number of flowers per plant and flower yield in African Marigold (*Tagetes erecta*).

Holcomb *et al.* (1991) observed in Chrysanthemum that foliar spray of 20 mg GA_3 per l increased the yield per plant. *Chrysanthemum morifolium* treated with GA_3 resulted in increased production of flowers per plant by 7.5 per cent at concentration of 100 ppm (El Keltawi *et al.*, 1996).

Dutta and Seemanthini (1997) obtained in Chrysanthemum a highest flower yield by number (438.0) and by weight (0.685 kg/plant) from GA_3 150 ppm treatment compared to control (213.3 and 0.263 kg) respectively.

Kulkarni *et al.* (1997) reported that in *Chrysanthemum morifolium* cv. Karnool treated with GA_3 recorded the highest yield (12.53 t/ha) followed by BR (8.46 t/ha) along with pinching. SA at 50 ppm registered increased total flower yield per plant. At 200 ppm concentration registered a higher value for 100 flower weight in China aster cv. Kamini (Ramesh, 1999).

2.3. Effect of Gibberellic acid and certain other chemicals on the physiochemical parameters

2.3.1. Chlorophyll content

BR treatment increased chlorophyll content in the primary leaves under radiation sources (Bhushan *et al.*, 1981). An increase in chlorophyll 'a', chlorophyll 'b' and total chlorophyll was recorded in Chrysanthemum treated with GA_3 at 250, 500 and 1000 ppm (Dahab *et al.*, 1987).

Nagarajaiah and Reddy (1986) recorded a significant reduction in chlorophyll content of the upper leaves when sprayed with 200 ppm of GA_3 in Rose cv. Queen Elizabeth. Chlorophyll a/b ratio was the highest with GA_3 100 ppm sprays in China aster cv. Kamini (Ramesh, 1999).

2.3.2. IAA oxidase content

The increase in auxin levels in the leaves of *Impatiens balsamina* receiving inductive photoperiods of GA_3 suggested that floral induction might be related to a lowering of the level of IAA oxidase (Kamlesh and Nanda, 1986). Ramesh (1999) indicated in China aster cv. Kamini, an increased auxin level when treated with BR at 0.25 ppm.

2.3.3. Total phenol content

SA is a ubiquitous plant constituent which in many cases has been found to have a positive effect on plant resistance (Malamy and Klessig, 1992).

In Carnation, dianthramide phytoalexins probably retard the growth of *Fusarium oxysporum* Race.2 thereby conferring resistance to the plant (Gerard and Harko Steijl, 1994).

Schlosser (1994) noticed that the quantity of biologically active pro-anthocyanidin (a pre-formed phenol) governs the differential resistance response in parts of *Cyclamen persicum* to *Botrytis cinerea.*

An increased phenolic content in Marigold, led to the biosynthesis of lignin which ultimately lignifies the cells, reduces shrinkage and loss of water, thus protecting the plants from moisture stress (Shyam *et al.,* 1994).

2.4. Effect of Gibberellic acid and certain other chemicals on post-harvest characters

2.4.1. Effect on vase life

The vase life of cut flowers can be extended by using various preservatives like sucrose, germicides, organic acids, non-toxic metallic salts and antioxidants. Generally the senescence and wilting of petals determine the longevity of the flower (Halevy and Mayak, 1979).

Two factors which play a major role in regulating the vase life of the flowers are carbohydrate supply and water balance. Water is the first and the self-evident need to excised flowers. Chemically fortified floral preservatives have been also shown to maintain turgor, decrease

microbial growth, prevents vascular blockage and allows easy flow of solutions.

Growth regulator treatment have shown to extend the flower longevity to a greater extent. Hew (1987) reported that asprin (acetyl salicylic acid) combined with sucrose enhanced flower opening in *Oncidium,* an ornamental Orchid species. An increase in vase life of Carnation cv. Improved margurite was observed by Jana and Kabir (1987) with foliar sprays of GA_3 at 100 ppm.

SA was found to increase flower longevity by inhibiting ethylene biosynthesis due to blockage caused in the conversion of 1-amino-cyclopropane carboxylic acid (1ACC) to ethylene (Leslie and Romani, 1988).

Caren D' hont *et al.* (1991) reported that GA_3 used in concentration from 1-5 ppm had a positive effect on leaves, retarding yellowing process. However, at lower concentration deformation of flowers was found.

Dehale *et al.* (1993) reported that GA_3 spray at 100 ppm caused an increase in vase life of Chrysanthemum cv. Flirt. Vase life of the cut China aster flowers was increased significantly by the spray of SA at 50 ppm (Ramesh, 1999).

The termination of vase life of cut flowers is characterised by wilting, even when flowers are constantly held in water. The flowers when kept in water constantly change their fresh weight (Rogers, 1973).

The retardation in water uptake coupled with continuous transpiration leads to water deficit and reduced turgidity in cut flowers (Halevy and Mayak, 1981). Dutta and Seemanthini (1997) obtained the highest vase life of Co.1 Chrysanthemum with foliar sprays of GA_3 at 150 ppm at the rate of 20 days as against 8.67 days in the control.

According to Deotale *et al.* (1995) GA_3 at 150 ppm produced flowers with the longest vase life (17.5 days) in Chrysanthemum cv. Raja. Further studies indicated that 0.1 per cent ammonium sulphate + 4 per cent sucrose extended the vase life upto 22.6 days.

(He Shen Gen *et al.* (1997) reported that epibrassinolide at 0.1 ppm concentration prolonged the vase life of cut China rose flowers as compared to distilled water or basic preservative only (2 % sucrose + 500 mg/l citric acid + 250 mg HQC + 25 ml $AgNO_3$). Epibrassinolide increased the fresh weight of cut flowers and increased reducing sugar content at the beginning of vase holding period.)

Nijis and De (1981) observed a fairly moderate keeping quality of China aster flowers in water. Gerbera placed in deionised water and tap water showed a vase life of 5.3 and 2.6 days respectively. Fluoride toxicity was the cause for reduction in the vase life of flowers kept in tap water (Tija *et al.*, 1987).

2.4.1.1. Extension of vase life using preservative

a. Effect of sucrose on vase life

Sucrose concentration influences fluid uptake and transpiration in cut flowers. Sucrose or preservatives containing carbohydrate substitute for the naturally depleting carbohydrates in cut flowers, reduced proteolysis. Coorts *et al.* (1965) reported that sucrose, sustained the quality, increased the weight and prolonged cut flower life of Snapdragon, Asters and Marigold.

Sugars were found effective in inducing bud growth and development delaying the abscission of the bud and flowers showing greater percentage of full bloomed flowers (Pathak *et al.*, 1979).

Mantur and Nalawadi (1989) noticed that in China aster an extended vase life of 8.0 and 8.3 days respectively with 2.0 per cent sucrose against control 5.0 and 7.4 days respectively in kharif and rabi seasons.

De and Bhattacharjee (1997) obtained improved bud opening and vase life in roses cv. Dr. B.P.Pal with 4 per cent sucrose and 100 ppm asprin solution. Sucrose at 5 per cent in combination with a biocide ($AgNo_3$ 25 ppm + citric acid 75 ppm) for Chrysanthemum substantially increased bud size and vase life (Kushal *et al.*, 1997).

Chrysanthemum morifolium cv. Kundan and Mountaineer kept in holding solution of 8-HQC (250 ppm) + Sucrose (1.5 %) had the longest

vase life, the greatest diameter and the lowest fresh weight loss in storage (Anju Bhat and Tripathi 1999).

b. Effect of aluminium salts on vase life

Aluminium salts are one among the various bactericidal chemicals that have been evaluated experimentally to improve cut flower vase life because of their inhibitory property against microbial organisms (Rogers, 1973).

Narayana Gowda (1986) reported that the vase life of Aster was the longest (13.17 to 14.63 days) with 0.4 per cent Aluminium sulphate ($Al_2(SO_4)_3$) and 2 per cent sucrose. Whereas the vase life in water was only 5.1 to 5.5 days.

When cut flowers of China aster were placed in 0.2 per cent $Al_2(SO_4)_3$ solution, the vase life was extended to 8.0 and 8.7 days in kharif and rabi season respectively (Mantur and Nalawadi, 1989). In cut roses, a combination of 5 per cent sucrose with 300 ppm $Al_2(SO_4)_3$ gave a vase life of 5 days compared with 3 days in control (Ahn and Um, 1991).

Rajagopalan and Khader (1993) recorded the longest vase life (10 and 11 days for Chrysanthemum cv. Co.1 and Co.2 respectively) when the flowers were kept under 0.1 per cent $Al_2(SO_4)_3$ holding solution, with the highest percentage of fresh weight increase and least damage to the flowers. The longest vase life of 15.7 days was recorded for China aster treated with 1.00 fm Aluminium sulphate.

c. Effect of silver salts on vase life

Silver thiosulphate (STS) improved longevity of cut flowers and potted plants by preventing abscission of leaves and petals. Improvement in vase life was attributed to inhibition of the production and action of ethylene by STS (Veen, 1983).

Increasing amount of ethylene during flower aging causes flower drop and fading. STS is one of the most effective antagonists against senescence in optimum concentrations to increase the shelf life of cut flowers (Fjeld and Mor 1985).

Vase life of cut Carnation flowers were extended by 1.8 times in solutions containing 5.0 per cent sucrose and 0.3 mM STS concentration along with an increase in the total sugar content of petals thereby reducing the senescence (Chung *et al.,* 1986). Increased fresh weight with no decay of stem and slow wilting of petals improved the vase life when treated with STS and sucrose in cut Chrysanthemum (Ketsa 1989).

Lee and Suh (1996) opined that the longevity and quality of Lilium hybrid was increased when the stems were held in holding solutions of 0.2 M $AgNO_3$ + 3.0 per cent sucrose. The silver ion holding solution increased the total vase life about 2 times when compared to the control.

Immature Chrysanthemum buds when treated with solution containing sucrose alone showed slimy growth of peduncle due to microbial growth. While buds kept in solution containing sucrose +

biocide ($AgNO_3$ 25 ppm + Citric acid 75 ppm) + BAP exhibited increased bud size (5.3 cm), as well as extended vase life (19.8 days) (Kushal *et al.*, 1997).

2.5. Correlation and regression studies

In 'White' and 'Yellow' cultivars of Chrysanthemum, Shanmugam *et al.* (1972) worked out correlation coefficients between the flower yield and each of the six characters, *viz.*, height at first flowering, total increase in height, number of laterals, duration of flowering, number of days to first flowering and size of flowers. All relationships were significant at five per cent level except for size of flowers in the 'White' cultivar and height at flowering in the 'Yellow' cultivar.

The association studies by Negi *et al.* (1983) in China aster revealed that number of flowers per plant showed positive significant association with number of branches per plant.

Chaugule (1985) in Chrysanthemum recorded the weight of flowers per plant to have a significant positive correlation with characters such as height and spread of plant, duration of flowering, number of branches per plant and shelf-life of flowers at both phenotypic and genotypic levels.

Positive and significant correlation was found between number of flowers per plant and number of branches per plant in Chrysanthemum (Chattopadhyay *et al.*, 1991).

Janakiram and Rao (1994) observed that in China aster, the number of days to flower had positive significant correlation with number of branches and flower size was negatively correlated with number of flowers per plant. Positive significant association was also observed between number of flowers and plant height, number of main branches per plant, number of lateral branches.

Jhon *et al.* (1994) found that plant height had positive significant correlation with days to flowering, duration of flowering and flower size. Flower weight and number of branches per plant with number of flowers in Zinnia.

Damke *et al.* (1998) reported that stepwise multiple regression analysis in Super Star roses indicated that number of shoots per plant, days taken for first flower bud appearance, flower bud opening and average stem length are four important characters which predict the total number of flowers with 91 per cent accuracy. The multiple regression analysis had, however indicated that longevity of flowers can be predicted with 99 per cent accuracy with only two variables like days taken for flower bud appearance and flower bud opening.

Sirohi and Behera (1999) reported a positive and significant phenotypic association of yield with flowers per plant, plant spread and number of branches per plant indicating that selections based on these characters would be more effective for Chrysanthemum improvement.

Materials and Methods

Chapter 3

MATERIALS AND METHODS

An experiment was laid out to study the effect of Gibberellic acid and certain other chemicals on cut flower production of four cultivars of Chrysanthemum (*Dendranthema grandiflora.* Tzelev.) in the Department of Floriculture and Landscaping, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore during the year 1999-2000. The experimental materials involved and the methodology adopted are described below.

3.1. Location of the experimental site

Field trial was conducted in the Botanical Gardens of the Department of Floriculture and Landscaping which is geographically situated between 11°02" North latitude and 76°57' East longitude at an altitude of 426.76 m above Mean Sea Level. The mean maximum and mean minimum temperature were 31.58°C and 21.07°C respectively. The relative humidity during the period was 85.83 per cent (Annexure II).

3.2. Materials

3.2.1. Cultivars

The following four cut flower cultivars were selected for the present study based on the preliminary observations. In addition, the loose flower

production were also recorded when the stalk length was not upto the specified standards for cut flower production.

CULTIVAR	COLOUR
Baggi	White
Indira	Aureolin
Red gold	Golden yellow
Shymal	Dodge purple

3.2.2. Gibberellic acid and other chemicals

Gibberellic acid (GA_3), Triacontanol (TR), Brassinolide (BR) and Salicylic acid (SA) were employed for the study. They were obtained from different companies as listed in Annexure I.

3.3. Methods

3.3.1. Experimental design and layout

The experimental design and layout are as follows:

Crop - Chrysanthemum (*Dendranthema grandiflora.* Tzelev.) cv. Baggi, Indira, Red gold and Shymal

Design - Split plot design

Number of treatments - 11

Replications - 2

3.3.2. Treatmental Details

Main plot

C_1 - Baggi

C_2 - Indira

C_3 - Red gold

C_4 - Shymal

Sub plot

T_1 - Gibberellic acid (GA_3) – 100 ppm

T_2 - Gibberellic acid (GA_3) – 150 ppm

T_3 - Salicylic acid (SA) – 50 ppm

T_4 - Salicylic acid (SA) – 100 ppm

T_5 - Triacontanol (TR) – 1 ppm

T_6 - Triacontanol (TR) – 2 ppm

T_7 - Triacontanol (TR) – 3 ppm

T_8 - Brassinolide (BR) – 0.1 ppm

T_9 - Brassinolide (BR) – 0.2 ppm

T_{10} - Brassinolide (BR) – 0.3 ppm

T_{11} - Control (Water spray)

3.4. Package of practices

3.4.1. Preparation of planting material

The terminal cuttings were taken from the mother plant during the month of March. These cuttings were planted in pots containing the

potting mixture of sand, red earth and organic matter in the ratio of 1:1:1. The pots were watered regularly.

3.4.2. Transplanting

Forty-five day old rooted cuttings were transplanted in ridges and furrows at a spacing of 30 x 30 cm. The total area of the main field being 14.256 m^2 with a individual plot size of 1.62 m^2.

The recommended fertilizer dose of 125:120:25 kg of NPK per hectare was applied. Half the dose of nitrogen and full dose of phosphorus and potassium were applied as basal, while the other half of nitrogen was applied 30 days after transplanting (Anon, 1999).

3.4.3. Treatment with growth substances

GA_3, TR, BR and SA were given as foliar sprays at three stages *viz.*, 30, 45 and 60 days after transplanting.

3.4.4. After cultivation

Pinching was done at sixth week after transplanting. Weeding and irrigation operations were carried out at regular intervals. Plant protection measures as and when required were taken up to control pests and diseases.

3.4.5. Harvesting

Cut flowers (sprays) were harvested at six days interval at unopened stage when only a few outer ray florets unfurled.

Observations recorded

Ten plants from each treatment were selected, tagged and the observations were recorded.

3.5. Morphological characters

3.5.1. Height of the plant

The height was measured at 30 days interval from the bottom of the plant to the growing point and the mean values were expressed in cm.

3.5.2. Number of branches at flowering

The branches arising from the main stem were counted at flowering and expressed as mean number per plant.

3.5.3. Number of suckers at flowering

The suckers arising from the mother plant were counted at flowering and the mean was expressed as number per plant.

3.6. Floral characters

3.6.1. Number of days taken to bud initiation

The number of days taken from the date of transplanting to the appearance of the first flower bud was counted, the mean was calculated and expressed as total number of days.

3.6.2. Number of days taken for flowering from bud initiation

The number of days taken from the date of bud initiation to first

flowering was counted, the mean was calculated and expressed as total number of days.

3.6.3. Number of days taken for 50 per cent flowering and duration of flowering

The number of days taken for 50 per cent flowering from date of transplanting and duration of flowering were counted, the mean was calculated and expressed as total number of days.

3.6.4. Length of stalk

The length of flower stalk from the point of origin to the point of flower pedicel attachment was measured and the mean was expressed in cm.

3.6.5. Length of spray

The length of spray from the point of origin to the point of longest flower pedicel attachment was measured and the mean was expressed in cm.

3.6.6. Diameter of the flower

Diameter of the flower was measured and the mean was expressed in cm.

3.6.7. Number of flowers per plant

Total number of flowers per plant was counted, the mean was worked out and expressed as number of flowers per plant.

3.6.8. Weight of individual flower

The weight of ten flowers from each treatment was weighed in electronic balance and the mean was expressed in grams.

3.6.9. Weight of 100 flowers

From each treatment, 100 flowers were collected, weighed in electronic balance and the mean was expressed in grams.

3.6.10. Flower yield per plant and per hectare

The flowers from the labelled plants were harvested separately, weighed in a electronic balance and the mean was expressed in grams per plant. Based on the yield per plant and plant population per hectare, the yield was calculated on hectare basis and expressed in kg per ha.

3.7. Physiochemical characters

The leaves from five selected plants in each treatment were randomly collected and analysis was done following standard procedures as described by different workers.

3.7.1. Chlorophyll content

Fresh leaves were collected at the vegetative stage. The chlorophyll 'a', chlorophyll 'b' and total chlorophyll content in leaves were determined by following the method of Yoshida *et al.* (1971) and expressed in mg per g of fresh weight.

3.7.2. IAA oxidase activity

Leaf samples were collected at both pre flowering and peak flowering stage and used for analysis. The enzyme IAA oxidase activity in the leaf sample was determined as per the method of Parthasarathi *et al.* (1970) calorimetrically at 540nm. The OD values were referred to a standard curve using auxin (IAA –10 to 100 µ g/l) and expressed in µg per gram per hour of the fresh sample.

3.7.3. Phenol content

Fresh leaves were collected at the vegetative stage. The total phenol content in the leaves was determined by following the method of Malik and Singh (1980) and expressed in mg per g of fresh weight.

3.8. Observations on post harvest life

3.8.1. Vase life

Holding solutions and their concentrations were fixed based on preliminary observations. The flower stalks were cut in the early morning and placed in different vase solutions, *viz.*, a) Plain water, b) Sucrose (2.0%), c) Sucrose (2.0%) + Aluminium sulphate (0.2%) and d) Sucrose (2.0%) + Silver nitrate (0.2%). The total number of days were counted till the petals started fading. The mean was calculated and expressed as number of days.

3.9. Statistical analysis

The data were subjected to statistical scrutiny wherever possible by following the methods described by Gomez and Gomez (1984).

3.9.1. Correlation and regression analysis

Correlation coefficient (r) and Regression coefficient (b) between yield and other related characters were calculated using the formula suggested by Rangaswamy (1995).

$$\text{Correlation coefficient (r)} = \frac{SP(XY)}{SS(X) * SS(Y)}$$

$$\text{Regression coefficient (b)} = \frac{SP(XY)}{SS(X)}$$

where,

SP (XY) - Sum of products between the two variable X and Y

SS (X) - Sum of squares of variable X

SS (Y) - Sum of squares of variable Y

* - Multiplication

Experimental Results

Chapter 4

EXPERIMENTAL RESULTS

The results of the investigations conducted to study the effect of Gibberellic acid and certain other chemicals on cut flower production of four cultivars of Chrysanthemum are presented below.

4.1. Morphological characters

4.1.1. Height of the plant

The height of the plant was recorded at 30, 60, 90 and 120 days after transplanting showed significantly varied performance.

4.1.1.1. At 30 days after transplanting (Table 1)

Significant differences were observed between the treatments of GA_3 and other chemicals, cultivar and their interactions. The cultivar Red Gold recorded the highest plant height of 13.63 cm, whereas the lowest height was observed in Indira (11.90 cm) which was on par with the cultivar Shymal with height of 12.14 cm.

GA_3 at 150 ppm exhibited the highest height of the plant (17.13 cm) followed by BR 0.2 ppm (15.52 cm). The lowest height of 9.03 cm was observed in TR 1 ppm.

The interaction effect between the cultivars and chemicals were highly significant. The greater value for plant height of 18.66 cm was

Table 1. Effect of Gibberellic acid and certain other chemicals on height of the plant (cm) in Chrysanthemum cultivars (30 DAP)

Treatments	Cultivar				Mean
	Baggi (C_1)	Indira (C_2)	Red Gold (C_3)	Shymal (C_4)	
Gibberellic acid 100 ppm (T_1)	14.13	13.64	15.76	13.11	14.16
Gibberellic acid 150 ppm (T_2)	18.66	15.61	18.47	15.79	17.13
Salicylic acid 50 ppm (T_3)	11.12	10.36	11.33	10.90	10.93
Salicylic acid 100 ppm (T_4)	12.51	12.17	14.10	12.63	12.85
Triacontanol 1 ppm (T_5)	9.36	8.51	8.94	9.31	9.03
Triacontanol 2 ppm (T_6)	10.95	9.87	9.74	10.07	10.16
Triacontanol 3 ppm (T_7)	11.45	10.90	12.22	11.06	11.41
Brassinolide 0.1 ppm (T_8)	12.44	11.30	13.59	12.12	12.36
Brassinolide 0.2 ppm (T_9)	16.29	14.31	17.31	14.17	15.52
Brassinolide 0.3 ppm (T_{10})	12.64	13.24	15.42	12.85	13.54
Control (Water spray) (T_{11})	12.08	11.05	13.10	11.57	11.95
Mean	12.87	11.90	13.63	12.14	

	C**	T**	C at T**	T at C**
SEd	0.11	0.20	0.39	0.39
CD (5 %)	0.36	0.40	0.82	0.79
CD (1 %)	0.65	0.53	1.15	1.06

** Highly significant

noticed in Baggi at GA_3 150 ppm, which was on par with Red Gold + GA_3 150 ppm (18.47 cm). The lesser value was recorded in the combination of Indira + TR 1 ppm (8.51 cm) which was on par with Red Gold + TR 1 ppm (8.94 cm), Shymal + TR 1 ppm (9.31 cm) and Baggi + TR 1 ppm (9.36 cm).

4.1.1.2. At 60 days after transplanting (Table 2)

Taller plants were observed with respect to cultivars, chemicals and their interactions. Significant results for the cultivar was observed for Baggi (29.94 cm) which was closely followed by Indira (28.86 cm) and the least in Shymal (25.37 cm).

GA_3 150 ppm produced in greater mean height of the plant (34.99 cm), which differed significantly from other treatments. The lowest mean value was found in TR 1 ppm (21.57 cm).

The interaction effect was highly significant in Baggi + GA_3 150 ppm (38.53 cm). While the lower mean value of 20.93 cm was obtained in Indira + TR 1 ppm. This was on par with Shymal + TR 1 ppm (21.19 cm). Baggi + TR 1 ppm (21.97 cm) and Shymal + TR 2 ppm (22.18 cm).

4.1.1.3. At 90 days after transplanting (Table 3)

Highly significant effects were obtained between cultivars, chemicals and their interactions. Height of the plant was the highest in Shymal (46.17 cm) which differed significantly from other cultivars. The lower mean value of 38.01 cm was obtained from Indira.

Table 2. Effect of Gibberellic acid and certain other chemicals on height of the plant (cm) in Chrysanthemum cultivars (60 DAP)

Treatments	Cultivar				Mean
	Baggi (C_1)	Indira (C_2)	Red Gold (C_3)	Shymal (C_4)	
Gibberellic acid 100 ppm (T_1)	33.60	32.49	28.29	27.28	30.41
Gibberellic acid 150 ppm (T_2)	38.53	34.31	34.88	32.25	34.99
Salicylic acid 50 ppm (T_3)	26.42	26.18	24.29	22.88	24.94
Salicylic acid 100 ppm (T_4)	30.61	29.90	27.19	24.80	28.12
Triacontanol 1 ppm (T_5)	21.97	20.93	22.20	21.19	21.57
Triacontanol 2 ppm (T_6)	25.40	25.25	23.29	22.18	24.03
Triacontanol 3 ppm (T_7)	27.35	27.60	25.35	23.45	25.94
Brassinolide 0.1 ppm (T_8)	29.86	28.68	26.27	24.46	27.32
Brassinolide 0.2 ppm (T_9)	34.94	33.07	30.31	30.46	32.19
Brassinolide 0.3 ppm (T_{10})	32.08	31.22	27.63	26.08	29.25
Control (Water spray) (T_{11})	28.60	27.84	25.82	24.05	26.57
Mean	29.94	28.86	26.86	25.37	

	C**	T**	C at T**	T at C**
SEd	0.19	0.37	0.73	0.74
CD (5 %)	0.62	0.75	1.54	1.50
CD (1 %)	1.13	1.00	2.14	2.01

** Highly significant

Table 3. Effect of Gibberellic acid and certain other chemicals on height of the plant (cm) in Chrysanthemum cultivars (90 DAP)

Treatments	Cultivar				Mean
	Baggi (C_1)	Indira (C_2)	Red Gold (C_3)	Shymal (C_4)	
Gibberellic acid 100 ppm (T_1)	47.61	41.54	47.54	49.42	46.52
Gibberellic acid 150 ppm (T_2)	52.50	45.56	55.59	53.21	51.71
Salicylic acid 50 ppm (T_3)	38.27	34.18	40.22	41.65	38.58
Salicylic acid 100 ppm (T_4)	46.03	39.12	43.80	47.47	44.10
Triacontanol 1 ppm (T_5)	34.20	30.36	38.85	40.13	35.88
Triacontanol 2 ppm (T_6)	36.67	32.80	39.98	40.60	37.51
Triacontanol 3 ppm (T_7)	40.87	35.94	41.78	43.62	40.55
Brassinolide 0.1 ppm (T_8)	**44.65**	**38.44**	**42.58**	**46.48**	**43.03**
Brassinolide 0.2 ppm (T_9)	49.79	43.03	49.43	51.45	48.42
Brassinolide 0.3 ppm (T_{10})	46.89	40.10	46.07	48.86	45.48
Control (Water spray) (T_{11})	43.07	37.07	42.20	45.04	41.84
Mean	43.68	38.01	44.36	46.17	

	C**	T**	C at T**	T at C**
SEd	0.18	0.31	0.62	0.62
CD (5 %)	0.58	0.63	1.32	1.26
CD (1 %)	1.06	0.84	1.85	1.69

** Highly significant

Among the chemicals GA_3 150 ppm expressed the highest mean value of 51.71 cm which was significantly higher from rest of the chemicals. The least value of 35.88 cm was observed from TR 1 ppm compared to control (water spray) (41.84 cm).

A higher value for interaction was noticed with the combination of Red Gold + GA_3 150 ppm (55.59 cm). This was followed by Shymal + GA_3 150 ppm (53.21 cm) and Baggi + GA_3 150 ppm (52.50 cm) which were on par. Whereas the lowest value of 30.36cm was recorded in Indira + TR 1 ppm.

4.1.1.4. At 120 days after transplanting (Table 4; Figure 1)

Among the cultivars, Shymal exhibited the highest value of 54.98 cm closely followed by Baggi (54.09 cm) and the least was Indira (45.43 cm). Between the chemical treatments GA_3 150 ppm showed the highest value of 61.00 cm for plant height while BR 0.2 ppm, SA 100 ppm and TR 3 ppm expressed increased plant height of 59.81 cm, 52.32 cm and 48.31 cm respectively compared to control (water spray) (49.89 cm).

The interaction also showed highly significant effects with respect to plant height. The combination of Shymal + GA_3 150 ppm recorded the greater value (67.88 cm) which was on par with Shymal + BR 0.2 ppm (67.20 cm). The lesser value was obtained in Indira + TR 1 ppm (38.63 cm).

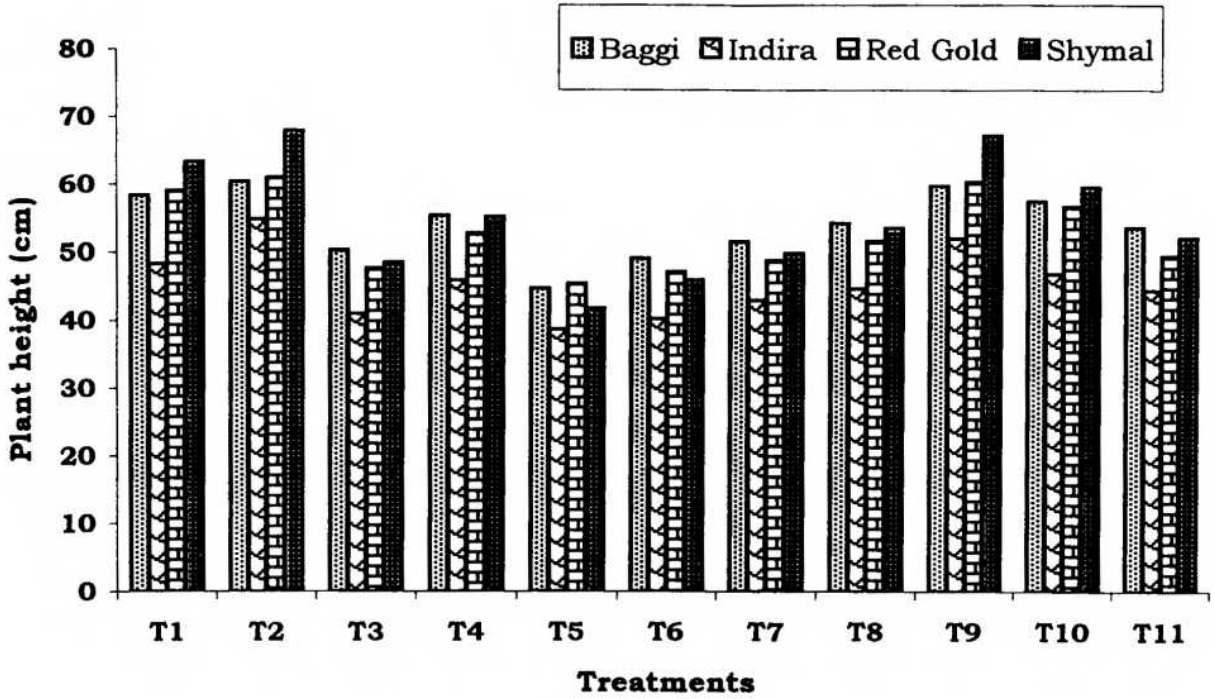
Table 4. Effect of Gibberellic acid and certain other chemicals on height of the plant (cm) in Chrysanthemum cultivars (120 DAP)

Treatments	Cultivar				Mean
	Baggi (C_1)	Indira (C_2)	Red Gold (C_3)	Shymal (C_4)	
Gibberellic acid 100 ppm (T_1)	58.39	48.31	59.12	63.36	57.29
Gibberellic acid 150 ppm (T_2)	60.41	54.81	60.92	67.88	61.00
Salicylic acid 50 ppm (T_3)	50.36	41.03	47.71	48.49	46.90
Salicylic acid 100 ppm (T_4)	55.39	45.87	52.79	55.26	52.32
Triacontanol 1 ppm (T_5)	44.71	38.63	45.40	41.70	42.61
Triacontanol 2 ppm (T_6)	49.11	40.25	47.13	45.87	45.59
Triacontanol 3 ppm (T_7)	51.54	42.98	48.85	49.87	48.31
Brassinolide 0.1 ppm (T_8)	54.30	44.70	51.67	53.48	51.03
Brassinolide 0.2 ppm (T_9)	59.72	52.01	60.31	67.20	59.81
Brassinolide 0.3 ppm (T_{10})	57.47	46.81	56.77	59.54	55.15
Control (Water spray) (T_{11})	53.61	44.36	49.44	52.15	49.89
Mean	54.09	45.43	52.74	54.98	

	C**	T**	C at T**	T at C**
SEd	0.18	0.38	0.74	0.75
CD (5 %)	0.58	0.76	1.55	1.52
CD (1 %)	1.06	1.02	2.15	2.04

** Highly significant

Fig. 1. Effect of Gibberellic acid and certain other chemicals on height of the plant (cm) in Chrysanthemum cultivars at 120 DAP



4.1.2. Number of branches per plant at flowering (Table 5; Figure 2)

The cultivars, chemicals and their interactions showed highly significant influence for the number of branches. The cultivar Red Gold recorded the higher score (13.07) for branch number which was on par with Indira (13.05). The lower value (10.57) was obtained from Shymal.

The chemical treatments had pronounced effect on the number of branches. The highest mean value of 13.30 which was produced in SA 100 ppm was on par with TR 3 ppm (13.28) compared to control (water spray) (11.25). The treatments GA_3 150 ppm (12.53) and BR 0.2 ppm (12.15) also increased the number of branches. The lowest value (10.58) was found in BR 0.1 ppm.

Red Gold + GA_3 150 ppm expressed the highest score of 15.75 which differed significantly from rest of the treatmental combinations. It was followed by Red Gold + SA 100 ppm (15.60). The least score was from the combination of Baggi + BR 0.1 ppm (9.65) which was on par with Shymal + GA_3 100 ppm (9.75).

4.1.3. Number of suckers per plant at flowering (Table 6)

Highly significant effects were obtained for cultivars and chemical treatments. Among the cultivars Baggi exhibited the higher number of suckers (4.86) followed by Shymal (3.45). The lowest value (2.25) was observed in Red Gold.

Table 5. Effect of Gibberellic acid and certain other chemicals on number of branches per plant at flowering in Chrysanthemum cultivars

Treatments	Cultivar				Mean
	Baggi (C_1)	Indira (C_2)	Red Gold (C_3)	Shymal (C_4)	
Gibberellic acid 100 ppm (T_1)	11.60	11.55	13.40	9.75	11.58
Gibberellic acid 150 ppm (T_2)	12.15	12.20	15.75	10.00	12.53
Salicylic acid 50 ppm (T_3)	10.85	13.35	12.45	10.70	11.84
Salicylic acid 100 ppm (T_4)	12.00	14.20	15.60	11.40	13.30
Triacontanol 1 ppm (T_5)	10.50	12.55	11.75	10.15	11.24
Triacontanol 2 ppm (T_6)	9.90	13.85	11.25	10.90	11.48
Triacontanol 3 ppm (T_7)	11.85	14.30	15.20	11.75	13.28
Brassinolide 0.1 ppm (T_8)	9.65	11.70	11.10	9.85	10.58
Brassinolide 0.2 ppm (T_9)	11.05	13.95	12.55	11.05	12.15
Brassinolide 0.3 ppm (T_{10})	11.30	13.00	13.10	10.40	11.95
Control (Water spray) (T_{11})	10.25	12.85	11.60	10.30	11.25
Mean	11.01	13.05	13.07	10.57	

	C**	T**	C at T**	T at C**
SEd	0.01	0.03	0.06	0.06
CD (5 %)	0.04	0.06	0.13	0.13
CD (1 %)	0.07	0.09	0.17	0.17

** Highly significant

Fig. 2 Effect of Gibberellic acid and certain other chemicals on number of branches per plant in Chrysanthemum cultivars

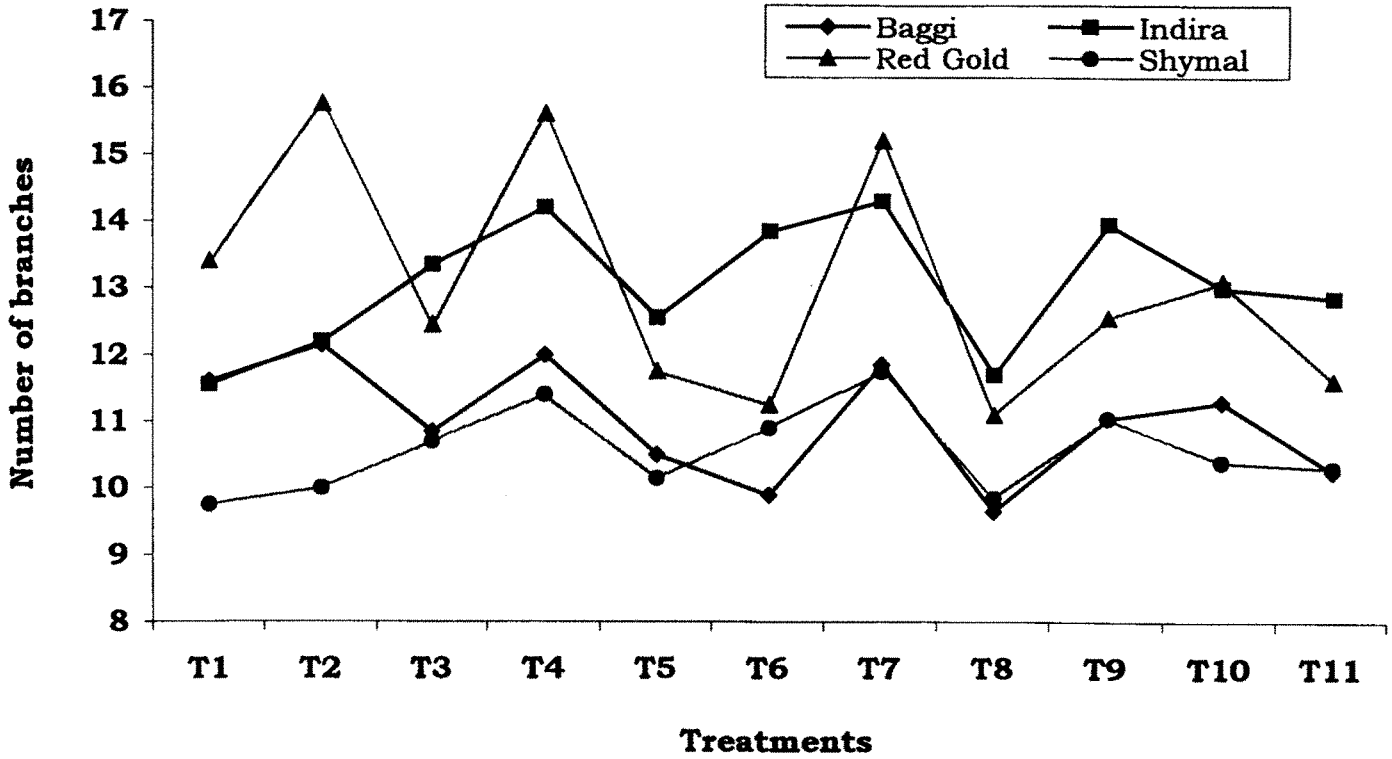


Table 6. Effect of Gibberellic acid and certain other chemicals on number of suckers per plant at flowering in Chrysanthemum cultivars

Treatments	Cultivar				Mean
	Baggi (C_1)	Indira (C_2)	Red Gold (C_3)	Shymal (C_4)	
Gibberellic acid 100 ppm (T_1)	4.30	1.85	1.75	2.85	2.69
Gibberellic acid 150 ppm (T_2)	4.45	1.95	2.10	2.95	2.86
Salicylic acid 50 ppm (T_3)	4.95	2.95	2.50	3.85	3.56
Salicylic acid 100 ppm (T_4)	5.45	3.35	2.35	4.05	3.80
Triacontanol 1 ppm (T_5)	4.55	2.40	2.20	3.15	3.08
Triacontanol 2 ppm (T_6)	4.95	2.85	2.60	3.55	3.49
Triacontanol 3 ppm (T_7)	5.55	3.15	2.30	3.95	3.74
Brassinolide 0.1 ppm (T_8)	4.35	2.05	2.20	3.05	2.91
Brassinolide 0.2 ppm (T_9)	5.25	2.90	2.25	3.65	3.51
Brassinolide 0.3 ppm (T_{10})	4.85	2.75	2.05	3.45	3.28
Control (Water spray) (T_{11})	4.80	2.65	2.40	3.40	3.31
Mean	4.86	2.62	2.25	3.45	

	C**	T**	C at T	T at C
SEd	0.05	0.13	NS	NS
CD (5 %)	0.15	0.26	NS	NS
CD (1 %)	0.28	0.34	NS	NS

** Highly significant
NS Non - significant

Between the chemicals SA 100 ppm, TR 3 ppm and SA 50 ppm were on par with the values of 3.80, 3.74 and 3.56 respectively. The least value of 2.69 was obtained from GA_3 100 ppm which was on par with GA_3 150 ppm (2.86) and BR 0.1 ppm (2.91).

4.2. Flower characters

4.2.1. Number of days taken for bud initiation (Table 7)

Significant results were obtained for the cultivars chemicals and their interactions. Between the cultivars Red Gold recorded the shorter period (48.05 days) for bud initiation which was on par with Indira (48.73 days). While Shymal required the longest period of 73.73 days.

Among the chemicals, SA 100 ppm needed the least period (49.13 days) followed by GA_3 150 ppm (50.00 days) compared to 56.75 days in the control (water spray). The other chemicals BR 0.3 ppm and TR 3 ppm have taken 53.75 days and 53.50 days respectively. The longer period (65.88 days) was obtained from TR 1 ppm.

The interaction also expressed significant results. Red Gold + GA_3 150 ppm showed the shorter duration (39.50 days) followed by Red Gold + SA 100 ppm (41.00 days). The longest duration (84.00 days) was obtained from Shymal + TR 1 ppm.

Table 7. Effect of Gibberellic acid and certain other chemicals on number of days taken for bud initiation in Chrysanthemum cultivars

Treatments	Cultivar				Mean
	Baggi (C_1)	Indira (C_2)	Red Gold (C_3)	Shymal (C_4)	
Gibberellic acid 100 ppm (T_1)	51.50	48.00	42.50	75.00	54.25
Gibberellic acid 150 ppm (T_2)	48.00	44.50	39.50	68.00	50.00
Salicylic acid 50 ppm (T_3)	57.00	43.00	51.00	66.50	54.38
Salicylic acid 100 ppm (T_4)	48.50	42.50	41.00	64.50	49.13
Triacontanol 1 ppm (T_5)	63.50	58.00	58.00	84.00	65.88
Triacontanol 2 ppm (T_6)	60.50	54.50	55.50	80.50	62.75
Triacontanol 3 ppm (T_7)	50.50	47.50	44.50	71.50	53.50
Brassinolide 0.1 ppm (T_8)	58.50	51.50	53.00	78.50	60.38
Brassinolide 0.2 ppm (T_9)	55.00	51.00	49.50	77.00	58.13
Brassinolide 0.3 ppm (T_{10})	52.50	46.50	46.00	70.00	53.75
Control (Water spray) (T_{11})	54.50	49.00	48.00	75.50	56.75
Mean	54.55	48.73	48.05	73.73	

	C**	T**	C at T**	T at C**
SEd	0.36	0.29	0.66	0.57
CD (5 %)	1.16	0.58	1.56	1.16
CD (1 %)	2.12	0.78	2.41	1.55

** Highly significant

4.2.2. Number of days taken for flowering from bud initiation (Table 8)

The cultivars, chemical substances and their interactions expressed significant effects. Among the cultivars, Indira exhibited shorter duration (59.73 days) which was on par with Baggi (60.14 days). The longest duration (76.09 days) was recorded in Shymal.

Between the chemical treatments, GA_3 150 ppm (54.25 days) differed significantly from other treatments which was followed by SA 100 ppm (55.63 days). The longer duration (75.00 days) was obtained from TR 1 ppm compared to 65.13 days in control (water spray) which was on par with BR 0.2 ppm (66.25 days).

The interaction between cultivar and chemicals were also highly significant. It was observed that the least number of days (50.00 days) was taken by the combination Indira + GA_3 150 ppm. It was on par with Red Gold + GA_3 150 ppm (50.00 days), Indira + SA 100 ppm (51.00 days), Baggi + GA_3 150 ppm (52.00 days), Indira + GA 100 ppm (52.00 days), Baggi + SA 100 ppm (52.50 days) and Red Gold + SA 100 ppm (52.50 days). Higher number of days (87.50 days) was recorded in Shymal + TR 1 ppm which was on par with Shymal + TR 200 ppm (85.50 days).

Table 8. Effect of Gibberellic acid and certain other chemicals on number of days taken for flowering from bud initiation in Chrysanthemum cultivars

Treatments	Cultivar				Mean
	Baggi (C_1)	Indira (C_2)	Red Gold (C_3)	Shymal (C_4)	
Gibberellic acid 100 ppm (T_1)	55.00	52.00	54.50	69.00	57.63
Gibberellic acid 150 ppm (T_2)	52.00	50.00	50.00	65.00	54.25
Salicylic acid 50 ppm (T_3)	63.50	64.50	65.00	80.50	68.38
Salicylic acid 100 ppm (T_4)	52.50	51.00	52.50	66.50	55.63
Triacontanol 1 ppm (T_5)	69.50	70.00	73.00	87.50	75.00
Triacontanol 2 ppm (T_6)	67.00	67.50	70.50	85.50	72.63
Triacontanol 3 ppm (T_7)	56.50	56.00	57.00	71.00	60.13
Brassinolide 0.1 ppm (T_8)	65.50	66.50	68.00	84.00	71.00
Brassinolide 0.2 ppm (T_9)	62.50	61.50	63.00	78.00	66.25
Brassinolide 0.3 ppm (T_{10})	58.00	58.00	58.50	74.00	62.13
Control (Water spray) (T_{11})	59.50	60.00	65.00	76.00	65.13
Mean	60.14	59.73	61.55	76.09	

	C**	T**	C at T*	T at C*
SEd	0.36	0.57	1.14	1.13
CD (5 %)	1.14	1.14	2.43	2.29
CD (1 %)	2.10	1.53	3.43	3.06

** Highly significant
* Significant

4.2.3. Number of days taken for 50 per cent flowering (Table 9; Figure 3)

Significant difference between cultivars, chemicals and their interactions were obtained for number of days taken for 50 per cent flowering. Among the cultivars, Indira exhibited the shortest period (115.41 days) for 50 per cent flowering followed by Red Gold (122.14 days). While Shymal recorded the longest period (157.50 days).

Between the chemicals, GA_3 150 ppm showed the least duration (123.38 days) followed by TR 3 ppm (124.50 days) compared to control (water spray) (132.00 days). Other chemicals like GA_3 100 ppm (126.25 days), BR 0.3 ppm (129.88 days) took relatively lesser number of days for 50 per cent flowering.

The interaction between Indira + TR 3 ppm had the shorter period of 106.00 days, while Shymal + TR 1 ppm expressed the longer period (168.50 days) for 50 per cent flowering.

4.2.4. Duration of flowering (Table 10; Figure 3)

The duration of flowering exhibited significant difference for cultivars, chemicals and their interactions. Between the cultivars Red Gold required 64.36 days with longer duration followed by Indira (59.45 days). While Shymal showed the shortest duration (23.05 days).

Among the chemicals GA_3 100 ppm recorded the longest duration (60.50 days) which was on par with SA 100 ppm (59.75 days). The lesser

Table 9. Effect of Gibberellic acid and certain other chemicals on number of days taken for 50 per cent flowering in Chrysanthemum cultivars

Treatments	Cultivar				Mean
	Baggi (C_1)	Indira (C_2)	Red Gold (C_3)	Shymal (C_4)	
Gibberellic acid 100 ppm (T_1)	125.50	111.50	117.00	151.00	126.25
Gibberellic acid 150 ppm (T_2)	123.00	108.00	113.50	149.00	123.38
Salicylic acid 50 ppm (T_3)	134.00	122.00	128.50	160.50	136.25
Salicylic acid 100 ppm (T_4)	124.50	126.50	135.50	150.50	134.25
Triacontanol 1 ppm (T_5)	141.50	112.00	119.00	168.50	135.25
Triacontanol 2 ppm (T_6)	137.50	109.50	115.50	165.50	132.00
Triacontanol 3 ppm (T_7)	127.50	106.00	111.00	153.50	124.50
Brassinolide 0.1 ppm (T_8)	135.00	123.50	130.50	163.00	138.00
Brassinolide 0.2 ppm (T_9)	132.00	119.50	126.50	159.50	134.38
Brassinolide 0.3 ppm (T_{10})	128.50	114.00	122.00	155.00	129.88
Control (Water spray) (T_{11})	130.00	117.00	124.50	156.50	132.00
Mean	130.82	115.41	122.14	157.50	

	C**	T**	C at T**	T at C**
SEd	0.19	0.41	0.80	0.82
CD (5 %)	0.59	0.83	1.67	1.66
CD (1 %)	1.08	1.11	2.30	2.22

** Highly significant

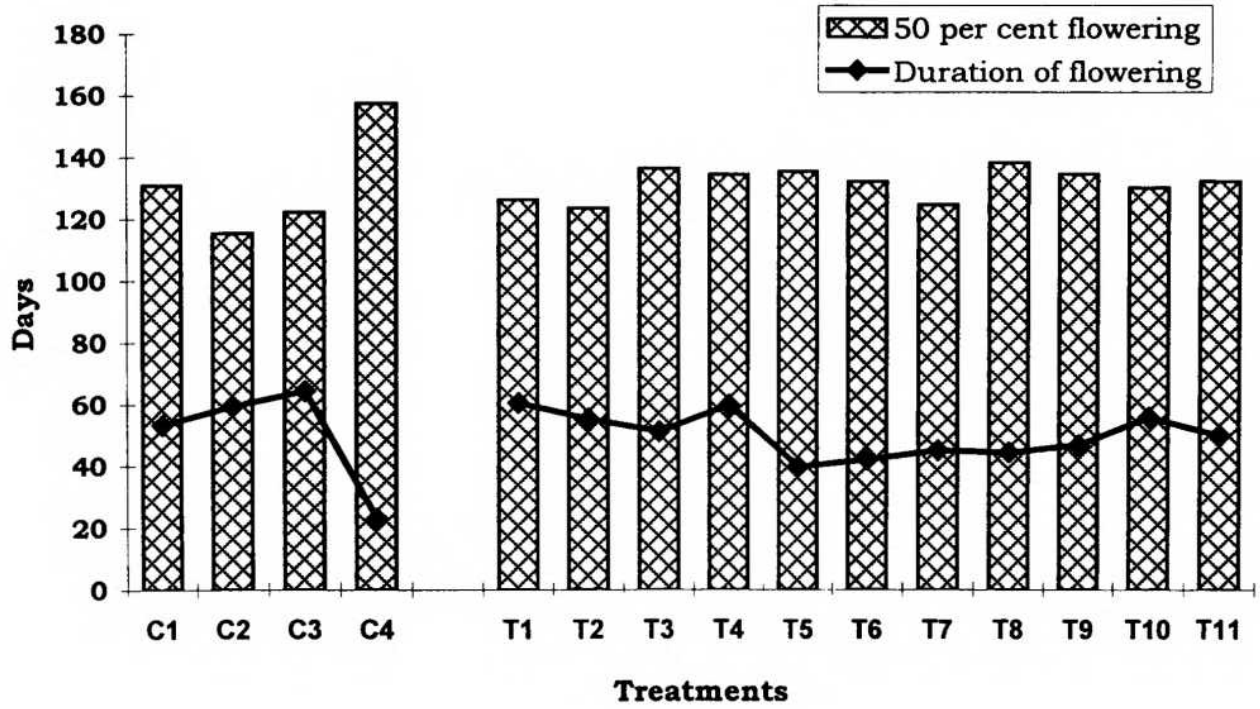
Table 10. Effect of Gibberellic acid and certain other chemicals on duration of flowering (days) in Chrysanthemum cultivars

Treatments	Cultivar				Mean
	Baggi (C_1)	Indira (C_2)	Red Gold (C_3)	Shymal (C_4)	
Gibberellic acid 100 ppm (T_1)	58.00	73.00	76.50	34.50	60.50
Gibberellic acid 150 ppm (T_2)	60.00	64.00	68.00	29.50	55.38
Salicylic acid 50 ppm (T_3)	54.50	61.50	66.00	23.00	51.25
Salicylic acid 100 ppm (T_4)	63.50	69.50	74.50	31.50	59.75
Triacontanol 1 ppm (T_5)	44.50	46.00	54.00	14.50	39.75
Triacontanol 2 ppm (T_6)	48.00	49.00	55.50	16.00	42.13
Triacontanol 3 ppm (T_7)	47.00	56.00	59.50	18.00	45.13
Brassinolide 0.1 ppm (T_8)	52.00	50.50	58.50	16.50	44.38
Brassinolide 0.2 ppm (T_9)	50.00	57.00	60.50	19.50	46.75
Brassinolide 0.3 ppm (T_{10})	56.00	67.50	71.00	28.50	55.75
Control (Water spray) (T_{11})	53.00	60.00	64.00	22.00	49.75
Mean	53.32	59.45	64.36	23.05	

	C**	T**	C at T**	T at C**
SEd	0.84	0.61	1.43	1.21
CD (5 %)	2.68	1.22	3.46	2.44
CD (1 %)	4.92	1.64	5.42	3.27

** Highly significant

Fig. 3. Effect of Gibberellic acid and certain other chemicals on days to 50 per cent flowering and duration of flowering in Chrysanthemum cultivars



duration (39.75 days) was obtained with TR 1 ppm compared to 49.75 days in control (water spray).

In the interaction, Red Gold + GA_3 100 ppm had the longer duration of 76.50 days, which was on par with Red Gold + SA 100 ppm (74.50 days). The lesser duration of 14.50 days was recorded in Shymal + TR 1 ppm which was on par with Shymal + TR 2 ppm (16.00 days) and Shymal + BR 0.1 ppm (16.50 days).

4.2.5. Length of flower stalk (Table 11; Figure 4)

Generally treatment with growth substances resulted in increased length of the stalk, compared to control (water spray). Significant differences were observed for cultivars, chemicals and their interactions.

Among the cultivars, Indira showed the highest value (23.90 cm) followed by Baggi (19.54 cm). The lowest value was from Red Gold (14.84 cm). Between the chemicals, GA_3 150 ppm recorded the larger value (28.09 cm), followed by GA_3 100 ppm (25.94 cm). The lower value of 11.21 cm was obtained in the control (water spray). Increased levels for length of stalk were observed for the treatments BR 0.3 ppm (23.97 cm), SA 100 ppm (20.23 cm) and TR 3 ppm (16.47 cm).

For the interaction, Indira + GA_3 150 ppm recorded the higher value (35.91 cm) followed by Indira + GA_3 100 ppm (33.09 cm). While the lower value (8.72 cm) was observed in Red Gold + Control (Water spray) which was on par with Red Gold + TR 1 ppm (9.53 cm).

Table 11. Effect of Gibberellic acid and certain other chemicals on length of the stalk (cm) in Chrysanthemum cultivars

Treatments	Cultivar				Mean
	Baggi (C_1)	Indira (C_2)	Red Gold (C_3)	Shymal (C_4)	
Gibberellic acid 100 ppm (T_1)	27.02	33.09	21.21	22.46	25.94
Gibberellic acid 150 ppm (T_2)	29.22	35.91	22.60	24.65	28.09
Salicylic acid 50 ppm (T_3)	16.67	18.36	10.90	14.60	15.13
Salicylic acid 100 ppm (T_4)	21.07	26.29	17.03	16.52	20.23
Triacontanol 1 ppm (T_5)	11.89	14.91	9.53	12.44	12.19
Triacontanol 2 ppm (T_6)	13.38	17.09	10.04	13.75	13.56
Triacontanol 3 ppm (T_7)	17.14	21.05	12.56	15.12	16.47
Brassinolide 0.1 ppm (T_8)	19.57	22.54	14.54	15.99	18.16
Brassinolide 0.2 ppm (T_9)	22.69	28.33	17.62	18.49	21.78
Brassinolide 0.3 ppm (T_{10})	25.16	31.11	18.50	21.13	23.97
Control (Water spray) (T_{11})	11.19	14.21	8.72	10.71	11.21
Mean	19.54	23.90	14.84	16.90	

	C**	T**	C at T**	T at C**
SEd	0.09	0.20	0.39	0.40
CD (5 %)	0.29	0.41	0.82	0.81
CD (1 %)	0.53	0.54	1.13	1.09

** Highly significant

4.2.6. Length of the spray (Table 12; Figure 4)

The length of spray exhibited significant differences when treated with growth substances. The cultivar Indira recorded the higher value of 57.22 cm followed by Baggi (55.13 cm). The lower value of 49.01 cm was found in Red Gold.

Among treatments GA_3 150 ppm showed a significantly longer spray length (58.38 cm) compared to rest of the treatments. It was followed by GA_3 100 ppm (56.65 cm), BR 0.3 ppm (55.95 cm), SA 100 ppm (53.65 cm) and TR 3 ppm (52.26 cm). The lower value (46.53 cm) was recorded in the control (water spray).

The interaction between Indira + GA_3 150 ppm exhibited the higher score for spray length (61.50 cm). While the lower value (40.07 cm) was obtained from Red Gold + Control (water spray).

4.2.7. Diameter of the flower (Table 13; Figure 5)

The cultivars, chemicals and their interactions were highly significant. Between the cultivars, Indira expressed the higher score (6.87 cm) followed by Shymal (6.72 cm). The lower value (4.60 cm) was exhibited by Baggi. Among the chemicals, BR 0.2 ppm exhibited the higher value (6.67 cm) followed by SA 100 ppm (6.42 cm) compared the control (5.52 cm). The other treatments, *viz.*, TR 3 ppm (6.25 cm) and GA_3 100 ppm (5.91 cm) also had increased flower diameter. The lower value was obtained from TR 1 ppm (4.78 cm).

Table 12. Effect of Gibberellic acid and certain other chemicals on length of the spray (cm) in Chrysanthemum cultivars

Treatments	Cultivar				Mean
	Baggi (C_1)	Indira (C_2)	Red Gold (C_3)	Shymal (C_4)	
Gibberellic acid 150 ppm (T_1)	57.70	59.90	53.84	55.18	56.65
Gibberellic acid 100 ppm (T_2)	58.87	61.50	55.71	57.45	58.38
Salicylic acid 50 ppm (T_3)	54.21	56.27	47.55	45.25	50.82
Salicylic acid 100 ppm (T_4)	55.87	56.66	50.53	51.54	53.65
Triacontanol 1 ppm (T_5)	52.62	53.49	43.29	43.07	48.11
Triacontanol 2 ppm (T_6)	53.51	54.69	44.42	43.68	49.07
Triacontanol 3 ppm (T_7)	54.65	57.33	49.32	47.73	52.26
Brassinolide 0.1 ppm (T_8)	55.14	58.28	50.11	49.61	53.28
Brassinolide 0.2 ppm (T_9)	56.12	59.18	51.84	52.48	54.90
Brassinolide 0.3 ppm (T_{10})	57.10	59.49	52.44	54.79	55.95
Control (Water spray) (T_{11})	50.68	52.66	40.07	42.71	46.52
Mean	55.13	57.22	49.01	49.41	

	C**	T**	C at T**	T at C**
SEd	0.11	0.26	0.50	0.51
CD (5 %)	0.34	0.52	1.04	1.04
CD (1 %)	0.63	0.70	1.43	1.39

** Highly significant

Fig. 4. Effect of Gibberellic acid and certain other chemicals on length of the stalk and length of the spray (cm) in Chrysanthemum cultivars

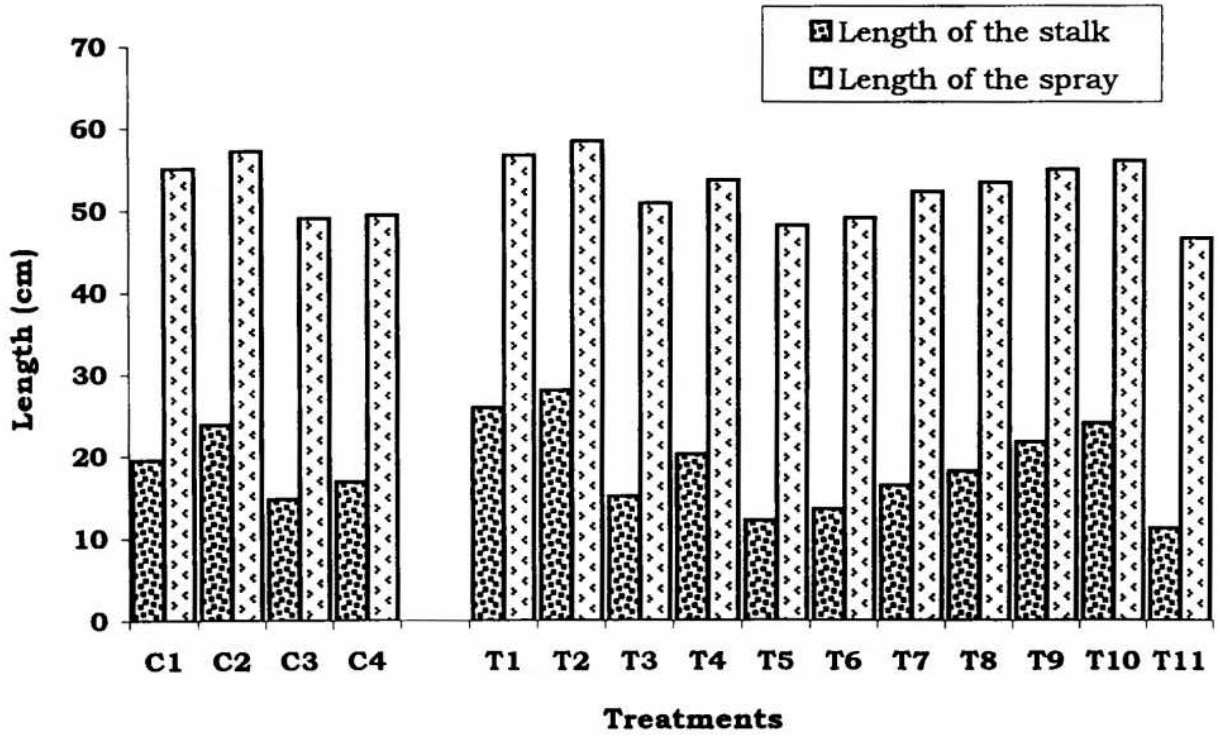


Table 13. Effect of Gibberellic acid and certain other chemicals on diameter of the flower (cm) in Chrysanthemum cultivars

Treatments	Cultivar				Mean
	Baggi (C_1)	Indira (C_2)	Red Gold (C_3)	Shymal (C_4)	
Gibberellic acid 100 ppm (T_1)	4.73	7.09	4.89	6.95	5.91
Gibberellic acid 150 ppm (T_2)	4.24	6.44	4.31	6.38	5.34
Salicylic acid 50 ppm (T_3)	4.55	6.90	4.77	6.74	5.74
Salicylic acid 100 ppm (T_4)	5.31	7.67	5.33	7.36	6.42
Triacontanol 1 ppm (T_5)	3.61	5.93	3.69	5.91	4.78
Triacontanol 2 ppm (T_6)	4.07	6.25	4.23	6.21	5.19
Triacontanol 3 ppm (T_7)	5.09	7.49	5.22	7.19	6.25
Brassinolide 0.1 ppm (T_8)	3.95	6.06	3.95	6.07	5.01
Brassinolide 0.2 ppm (T_9)	5.77	7.88	5.52	7.50	6.67
Brassinolide 0.3 ppm (T_{10})	4.99	7.28	5.10	7.08	6.11
Control (Water spray) (T_{11})	4.34	6.62	4.54	6.58	5.52
Mean	4.60	6.87	4.68	6.72	

	C**	T**	C at T**	T at C**
SEd	0.02	0.03	0.06	0.06
CD (5 %)	0.06	0.06	0.12	0.12
CD (1 %)	0.10	0.08	0.17	0.15

** Highly significant

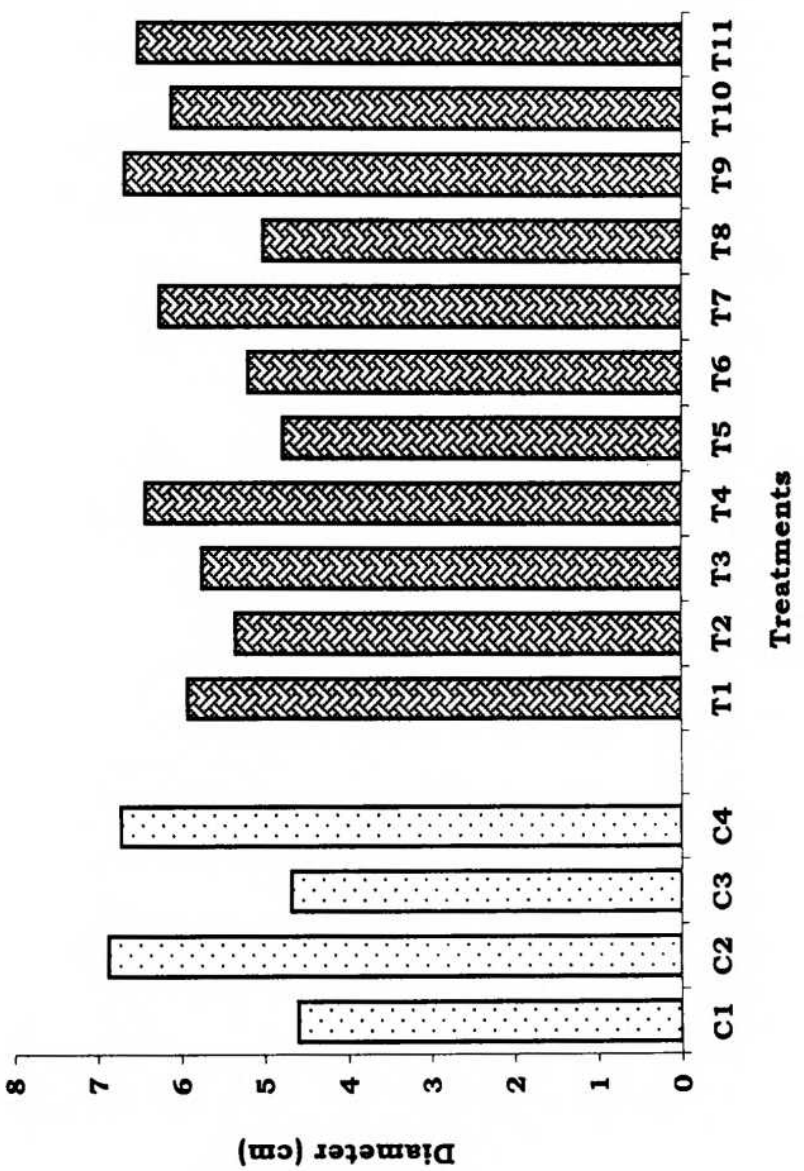


Fig. 5. Effect of Gibberellic acid and certain other chemicals on diameter of the flower (cm) in Chrysanthemum cultivars

The interaction between Indira + BR 0.2 ppm showed greater value (7.88 cm) followed by Indira + SA 100 ppm (7.67 cm). The lowest score was obtained from Baggi + TR 1 ppm (3.61 cm), which was on par with Red Gold + TR 1 ppm (3.69 cm).

4.2.8. Number of flowers per plant (Table 14; Figure 6)

Red Gold registered the higher number of flowers per plant (118.25) which varied significantly from the rest of the cultivars. It was followed by Baggi (105.05). The lowest value of 30.86 was obtained from Shymal.

Among the chemicals, TR 3 ppm recorded the highest score (93.23) followed by SA 100 ppm (91.70). GA_3 150 ppm (81.48) and BR 0.1 ppm (80.15) also registered relatively more number of flowers compared to the control (71.73).

The combination of Red Gold + TR 3 ppm (139.10) had the superior performance followed by Red Gold + SA 100 ppm (133.60). While, Shymal + BR 0.2 ppm exhibited poor performance (21.70) which was on par with Shymal + BR 0.3 ppm (22.00).

4.2.9. Weight of single flower (Table 15)

The weight of individual flowers did not vary much with the treatments. However, the cultivars, chemicals and their interactions differed significantly. Between the cultivars, Shymal registered the larger

Table 14. Effect of Gibberellic acid and certain other chemicals on number of flowers per plant in Chrysanthemum cultivars

Treatments	Cultivar				Mean
	Baggi (C_1)	Indira (C_2)	Red Gold (C_3)	Shymal (C_4)	
Gibberellic acid 100 ppm (T_1)	95.90	79.30	105.00	45.70	81.47
Gibberellic acid 150 ppm (T_2)	91.80	69.40	100.70	35.10	74.25
Salicylic acid 50 ppm (T_3)	100.50	58.00	113.40	25.80	74.43
Salicylic acid 100 ppm (T_4)	118.50	73.50	133.60	41.20	91.70
Triacontanol 1 ppm (T_5)	94.40	53.30	102.60	23.70	68.50
Triacontanol 2 ppm (T_6)	109.60	65.20	124.90	32.30	83.00
Triacontanol 3 ppm (T_7)	126.00	70.60	139.10	37.20	93.23
Brassinolide 0.1 ppm (T_8)	105.70	61.60	123.40	29.90	80.15
Brassinolide 0.2 ppm (T_9)	103.30	50.50	117.90	21.10	73.35
Brassinolide 0.3 ppm (T_{10})	112.10	52.00	130.50	22.00	79.15
Control (Water spray) (T_{11})	97.70	54.70	109.60	24.90	71.73
Mean	105.05	62.55	118.25	30.86	

	C**	T**	C at T**	T at C**
SEd	0.25	0.46	0.91	0.91
CD (5 %)	0.79	0.92	1.91	1.85
CD (1 %)	1.45	1.24	2.66	2.47

** Highly significant

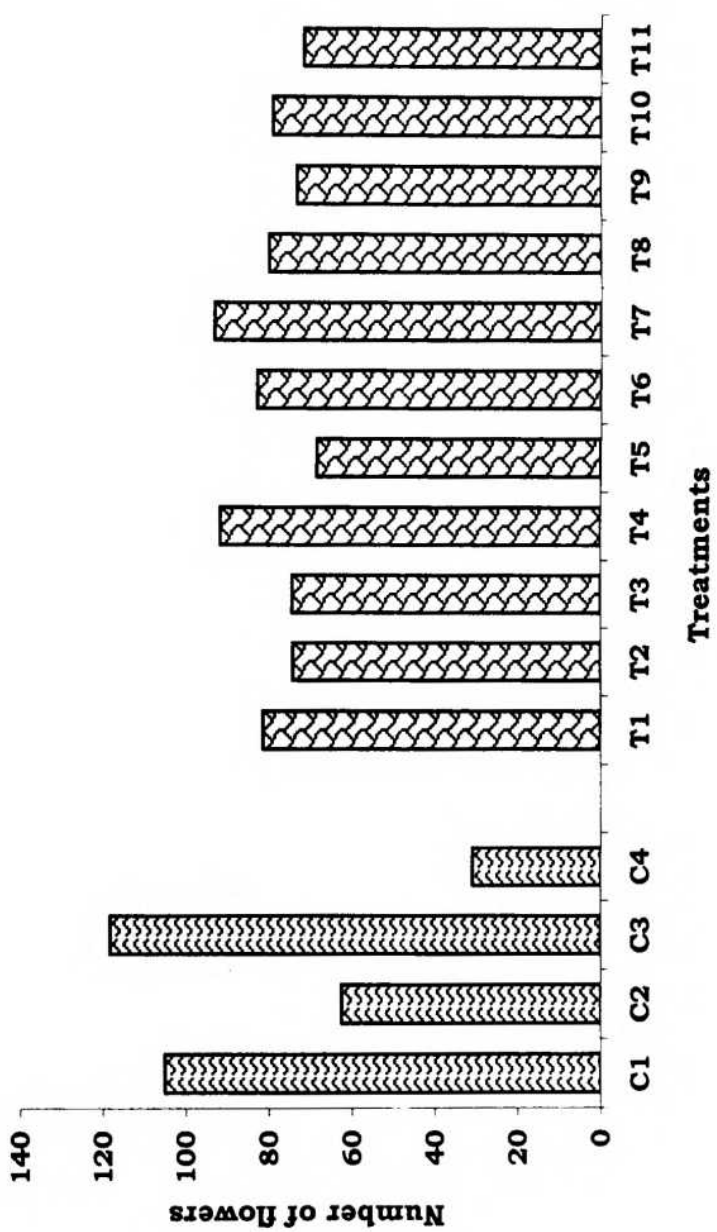


Fig. 6. Effect of Gibberellic acid and certain other chemicals on number of flowers per plant in Chrysanthemum cultivars

Table 15. Effect of Gibberellic acid and certain other chemicals on weight of single flower (g) in Chrysanthemum cultivars

Treatments	Cultivar				Mean
	Baggi (C_1)	Indira (C_2)	Red Gold (C_3)	Shymal (C_4)	
Gibberellic acid 100 ppm (T_1)	1.09	1.83	2.02	2.61	1.89
Gibberellic acid 150 ppm (T_2)	1.33	3.32	3.08	3.93	2.66
Salicylic acid 50 ppm (T_3)	2.27	2.42	2.66	2.39	2.68
Salicylic acid 100 ppm (T_4)	2.97	2.61	2.77	4.09	3.11
Triacontanol 1 ppm (T_5)	1.21	1.85	2.08	2.83	1.99
Triacontanol 2 ppm (T_6)	2.05	2.29	2.44	3.31	2.52
Triacontanol 3 ppm (T_7)	2.76	1.79	1.96	3.80	2.58
Brassinolide 0.1 ppm (T_8)	1.66	2.09	2.20	3.16	2.28
Brassinolide 0.2 ppm (T_9)	2.49	2.89	2.90	3.65	2.98
Brassinolide 0.3 ppm (T_{10})	1.89	2.23	2.32	3.26	2.43
Control (Water spray) (T_{11})	1.57	1.99	2.18	2.96	2.17
Mean	1.93	2.31	2.42	3.27	

	C**	T**	C at T**	T at C**
SEd	0.01	0.02	0.04	0.04
CD (5 %)	0.04	0.04	0.09	0.09
CD (1 %)	0.08	0.06	0.13	0.11

** Highly significant

weight (3.27 g) followed by Red Gold (2.42 g). Poor performance in Baggi (1.93 g) indicated the lower weight of the flower. Among the chemicals, SA 100 ppm was found to have higher flower weight (3.11 g) followed by BR 0.2 ppm (2.98 g). The treatments GA_3 150 ppm (2.66 g) and TR 3ppm (2.58 g) also registered marked score compared to the control (water spray) (2.17 g). GA_3 100 ppm expressed the lowest weight of 1.89 g.

Among the interactions, Shymal + SA 100 ppm recorded the highest weight of flower (4.09 g) followed by Shymal + TR 3 ppm (3.81 g), while the lowest value was recorded in Baggi + GA_3 100 ppm (1.09 g).

4.2.10. Weight of 100 flowers (Table 16)

The cultivars and chemicals treatment were highly significant. Among the cultivars, mean weight of 100 flowers was the highest (327.59 g) in Shymal, while Baggi expressed the lowest value (198.43 g). Between the chemicals, SA 50 ppm recorded the highest value (336.53 g) followed by BR 0.2 ppm (306.73 g), TR 3 ppm and TR 2 ppm exhibited the weight of 258.78 g and 255.76 g respectively which were on par. The lowest value of 190.10 g was obtained from GA_3 100 ppm compared to control (water spray) (218.37 g).

Among the interactions, Shymal + SA 50 ppm recorded the higher weight of 404.85 g followed by Shymal + TR 3 ppm (385.03 g). The lowest weight of 115.20 g was obtained from Baggi + GA_3 100 ppm.

Table 16. Effect of Gibberellic acid and certain other chemicals on weight of hundered flowers (g) in Chrysanthemum cultivars

Treatments	Cultivar				Mean
	Baggi (C_1)	Indira (C_2)	Red Gold (C_3)	Shymal ($_4$)	
Gibberellic acid 100 ppm (T_1)	115.20	180.97	201.61	262.61	190.10
Gibberellic acid 150 ppm (T_2)	135.05	245.44	263.72	290.60	233.70
Salicylic acid 50 ppm (T_3)	300.11	331.51	309.66	404.85	336.53
Salicylic acid 100 ppm (T_4)	228.27	263.68	279.23	336.17	276.84
Triacontanol 1 ppm (T_5)	119.16	187.39	207.68	283.30	199.38
Triacontanol 2 ppm (T_6)	208.60	236.13	247.52	330.80	255.76
Triacontanol 3 ppm (T_7)	278.77	178.08	193.25	385.03	258.78
Brassinolide 0.1 ppm (T_8)	176.37	212.62	222.48	309.67	230.28
Brassinolide 0.2 ppm (T_9)	264.33	298.44	294.70	369.47	306.73
Brassinolide 0.3 ppm (T_{10})	197.52	215.67	235.46	330.80	244.86
Control (Water spray) (T_{11})	159.41	198.73	215.14	300.20	218.37
Mean	198.43	231.69	242.77	327.59	

	C**	T**	C at T**	T at C**
SEd	1.15	1.80	3.63	3.61
CD (5 %)	3.67	3.64	7.76	7.29
CD (1 %)	6.74	4.88	10.96	9.75

** Highly significant

4.2.11. Yield per plant and calculated yield per hectare (Tables 17,18; Figure 7)

Gibberellic acid and other chemicals exhibited highly significant effects on yield of flowers per plant and calculated yield per hectare.

Among the cultivars, Red Gold exhibited higher yield of 288.45 g and 32050.02 kg per plant and per hectare respectively. While Shymal recorded the poorest performance of 100.86 g and 11205.99 kg per plant and per hectare respectively.

Between the chemicals, SA 100 ppm produced 248.09 g and 27564.97 kg per plant and per hectare respectively over the control (water spray) (146.69 g and 16299.01 kg). The lowest yield of 122.44 g per plant and 13604.01 kg per hectare were obtained from TR 1 ppm which were on par with GA_3 100 ppm with 123.03 per plant and 13670.40 kg per hectare.

Among the interactions, the highest yield per plant (370.65 g) and calculated yield per hectare (41182.74 kg) were recorded in the treatment combinations of Red Gold + SA 100 ppm. It was followed by Red Gold + BR 0.3 ppm (352.85 g and 39149.96 kg) respectively.

4.3. Physiochemical parameters

4.3.1. Chlorophyll content (mg/g) in leaf

The effects of different growth substances on synthesis of chlorophyll and components of chlorophyll *viz.*, chlorophyll 'a',

Table 17. Effect of Gibberellic acid and certain other chemicals on yield per plant (g) in Chrysanthemum cultivars

Treatments	Cultivar				Mean
	Baggi (C_1)	Indira (C_2)	Red Gold (C_3)	Shymal (C_4)	
Gibberellic acid 100 ppm (T_1)	106.07	96.29	222.41	67.38	123.03
Gibberellic acid 150 ppm (T_2)	122.56	203.75	200.81	61.19	147.08
Salicylic acid 50 ppm (T_3)	248.71	170.93	347.07	126.99	223.42
Salicylic acid 100 ppm (T_4)	295.04	175.72	370.65	150.94	248.09
Triacontanol 1 ppm (T_5)	113.98	101.36	211.53	62.89	122.44
Triacontanol 2 ppm (T_6)	226.08	161.50	271.82	92.44	187.96
Triacontanol 3 ppm (T_7)	284.57	90.76	287.97	101.26	191.14
Brassinolide 0.1 ppm (T_8)	173.57	129.60	321.62	114.07	184.71
Brassinolide 0.2 ppm (T_9)	276.58	180.45	342.49	121.13	230.16
Brassinolide 0.3 ppm (T_{10})	205.31	136.33	352.35	133.88	206.97
Control (Water spray) (T_{11})	154.95	110.24	244.26	77.33	146.69
Mean	200.67	141.54	288.45	100.86	

	C**	T**	C at T**	T at C**
SEd	2.03	1.19	3.05	2.39
CD (5 %)	6.45	2.41	7.72	4.82
CD (1 %)	11.84	3.23	12.47	6.45

** Highly significant

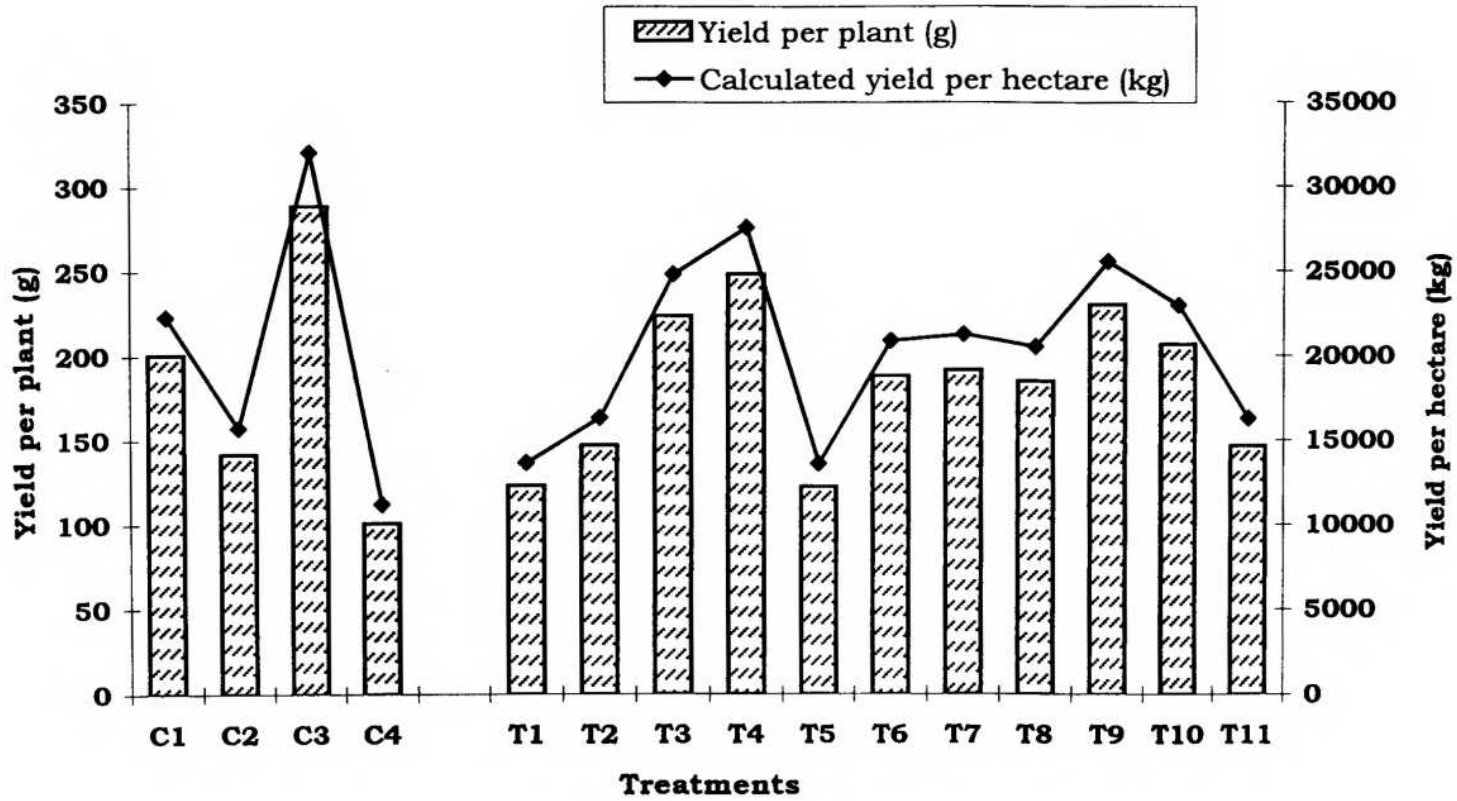
Table 18. Effect of Gibberellic acid and certain other chemicals on calculated yield per hectare (Kg) in Chrysanthemum cultivars

Treatments	Cultivar				Mean
	Baggi (C_1)	Indira (C_2)	Red Gold (C_3)	Shymal (C_4)	
Gibberellic acid 100 ppm (T_1)	11784.99	10698.32	24712.20	7486.10	13670.40
Gibberellic acid 150 ppm (T_2)	13617.21	22638.87	22312.20	6798.33	16341.65
Salicylic acid 50 ppm (T_3)	27634.42	18991.65	38563.30	14109.43	24824.70
Salicylic acid 100 ppm (T_4)	32781.64	19524.43	41182.74	16771.10	27564.97
Triacontanol 1 ppm (T_5)	12663.88	11261.66	23503.31	6987.21	13604.01
Triacontanol 2 ppm (T_6)	25119.94	17944.43	30201.64	10270.55	20884.14
Triacontanol 3 ppm (T_7)	31619.41	10084.99	31996.63	11251.65	21238.17
Brassinolide 0.1 ppm (T_8)	19284.99	14399.99	35734.97	12674.44	20523.59
Brassinolide 0.2 ppm (T_9)	30731.08	20049.42	38053.85	13458.88	25573.31
Brassinolide 0.3 ppm (T_{10})	22812.20	15147.21	39149.96	14866.54	22993.98
Control (Water spray) (T_{11})	17216.65	12248.33	27139.42	8591.66	16299.01
Mean	22296.94	15726.30	32050.02	11205.99	

	C**	T**	C at T**	T at C**
SEd	225.28	132.75	338.87	265.50
CD (5 %)	716.94	268.30	858.82	536.60
CD (1 %)	1316.02	359.02	1386.31	718.03

** Highly significant

Fig. 7. Effect of Gibberellic acid and certain other chemicals on yield per plant (g) and calculated yield per hectare (kg) in Chrysanthemum cultivars



chlorophyll 'b' and total chlorophyll were investigated. The results are furnished below.

4.3.1.1. Chlorophyll 'a' content (mg/g) in leaves (Table 19)

Chlorophyll 'a' content showed highly significant results with cultivars, chemicals and their interactions. Among the cultivars, Baggi recorded the highest value (1.051) and the lowest value of 0.311 was recorded in Indira. Between the chemicals, BR 0.3 ppm held the superior trend (0.802) followed by SA 50 ppm (0.772). The lowest value of 0.460 was in TR 2 ppm compared to control (water spray) (0.499).

The interaction showed significant effect with Baggi + BR 0.3 ppm (1.416) at the highest followed by Baggi + SA 50 ppm (1.379). The least was from Indira + TR 2 ppm (0.189).

4.3.1.2. Chlorophyll 'b' (mg/g) in leaves (Table 20)

Chlorophyll 'b' content also showed similar trend as that of chlorophyll 'a'. The cultivar Baggi expressed the best performance of 0.511. While Indira recorded the lowest value of 0.160. The treatment BR 0.3 ppm held the highest score of (0.462) which was followed by GA_3 150 ppm (0.376) were on par with SA 50 ppm (0.369). The control (water spray) registered 0.212 for chlorophyll 'b' content. Among the interactions, the highest value of 0.863 was observed in Baggi + BR 0.3 ppm.

Table 19. Effect of Gibberellic acid and certain other chemicals on chlorophyll 'a' content (mg g^{-1}) at vegetative stage in Chrysanthemum cultivars

Treatments	Cultivar				Mean
	Baggi (C_1)	Indira (C_2)	Red Gold (C_3)	Shymal (C_4)	
Gibberellic acid 100 ppm (T_1)	1.136	0.338	0.506	0.699	0.670
Gibberellic acid 150 ppm (T_2)	1.228	0.349	0.529	0.736	0.711
Salicylic acid 50 ppm (T_3)	1.379	0.377	0.583	0.749	0.772
Salicylic acid 100 ppm (T_4)	0.935	0.294	0.380	0.591	0.550
Triacontanol 1 ppm (T_5)	0.883	0.278	0.337	0.560	0.515
Triacontanol 2 ppm (T_6)	0.808	0.189	0.336	0.508	0.460
Triacontanol 3 ppm (T_7)	1.030	0.320	0.490	0.690	0.634
Brassinolide 0.1 ppm (T_8)	0.943	0.299	0.397	0.610	0.562
Brassinolide 0.2 ppm (T_9)	0.950	0.309	0.426	0.643	0.582
Brassinolide 0.3 ppm (T_{10})	1.416	0.411	0.609	0.771	0.802
Control (Water spray) (T_{11})	0.854	0.257	0.349	0.536	0.499
Mean	1.051	0.311	0.449	0.645	

	C**	T**	C at T**	T at C**
SEd	0.005	0.005	0.011	0.010
CD (5 %)	0.016	0.010	0.025	0.020
CD (1 %)	0.030	0.014	0.037	0.027

** Highly significant

Table 20. Effect of Gibberellic acid and certain other chemicals on chlorophyll 'b' content (mg g^{-1}) at vegetative stage in Chrysanthemum cultivars

Treatments	Cultivar				Mean
	Baggi (C_1)	Indira (C_2)	Red Gold (C_3)	Shymal (C_4)	
Gibberellic acid 100 ppm (T_1)	0.535	0.185	0.259	0.335	0.329
Gibberellic acid 150 ppm (T_2)	0.645	0.224	0.286	0.347	0.376
Salicylic acid 50 ppm (T_3)	0.584	0.199	0.313	0.378	0.369
Salicylic acid 100 ppm (T_4)	0.416	0.131	0.178	0.273	0.249
Triacontanol 1 ppm (T_5)	0.403	0.124	0.149	0.248	0.231
Triacontanol 2 ppm (T_6)	0.357	0.104	0.105	0.210	0.194
Triacontanol 3 ppm (T_7)	0.510	0.160	0.230	0.310	0.309
Brassinolide 0.1 ppm (T_8)	0.426	0.135	0.196	0.293	0.263
Brassinolide 0.2 ppm (T_9)	0.484	0.146	0.216	0.310	0.289
Brassinolide 0.3 ppm (T_{10})	0.863	0.234	0.344	0.406	0.462
Control (Water spray) (T_{11})	0.391	0.116	0.118	0.222	0.212
Mean	0.511	0.160	0.218	0.304	

	C**	T**	C at T**	T at C**
SEd	0.003	0.004	0.009	0.008
CD (5 %)	0.010	0.008	0.019	0.017
CD (1 %)	0.019	0.011	0.027	0.022

** Highly significant

4.3.1.3. Total chlorophyll content (mg/g) in leaves (Table 21)

In general, total chlorophyll content was increased by all the treatments. However, the cultivar and chemical treatments were highly significant. Baggi recorded the highest value (1.582) followed by Shymal (1.160). The treatment BR 0.3 ppm exhibited the higher value of 1.458 which was on par with SA 50 ppm (1.409). Among the interaction, Baggi + BR 0.3 ppm recorded the highest value of 2.358.

4.3.2. IAA oxidase activity (µg/g/h) (Tables 22, 23)

The growth regulator and other chemicals like GA_3, SA, BR and TR at higher concentrations significantly increased the auxin content over the control (water spray).

The cultivar Indira recorded the highest score of 3032.718 and 3265.182 for pre-flowering and peak flowering stages respectively. In the chemical treatment, GA_3 150 ppm recorded 3062.375 and 3440.375 for pre flowering and peak flowering stages respectively. While the control (water spray) recorded 2495.550 and 2796.950 for pre and peal flowering stages respectively.

The interaction in both stages, Indira + GA_3 150 ppm (3377.300 and 3593.400) expressed the greatest performance at pre flowering and peak flowering stages respectively. While the combination of Shymal + TR 2 ppm recorded 1821.700 and 2136.300 poor performance at pre and peak flowering stages respectively.

Table 21. Effect of Gibberellic acid and certain other chemicals on total chlorophyll content (mg g^{-1}) at vegetative stage in cultivars

Treatments	Cultivar				Mean
	Baggi (C_1)	Indira (C_2)	Red Gold (C_3)	Shymal (C_4)	
Gibberellic acid 100 ppm (T_1)	1.688	0.492	0.792	1.338	1.078
Gibberellic acid 150 ppm (T_2)	1.984	0.582	0.839	1.483	1.222
Salicylic acid 50 ppm (T_3)	2.275	0.614	0.963	1.783	1.409
Salicylic acid 100 ppm (T_4)	1.294	0.406	0.553	1.128	0.845
Triacontanol 1 ppm (T_5)	1.265	0.377	0.532	1.033	0.802
Triacontanol 2 ppm (T_6)	1.138	0.283	0.457	1.028	0.727
Triacontanol 3 ppm (T_7)	1.450	0.470	0.730	0.990	0.915
Brassinolide 0.1 ppm (T_8)	1.325	0.417	0.589	0.819	0.787
Brassinolide 0.2 ppm (T_9)	1.375	0.422	0.668	0.851	0.829
Brassinolide 0.3 ppm (T_{10})	2.358	0.788	1.138	1.547	1.458
Control (Water spray) (T_{11})	1.240	0.330	0.441	0.759	0.693
Mean	1.582	0.472	0.701	1.160	

	C**	T**	C at T**	T at C**
SEd	0.117	0.066	0.172	0.132
CD (5 %)	0.373	0.133	0.440	0.266
CD (1 %)	0.685	0.178	0.716	0.356

** Highly significant

Table 22. Effect of Gibberellic acid and certain other chemicals on IAA oxidase activity* ($\mu g\ g^{-1}h^{-1}$) at pre-flowering stage in Chrysanthemum cultivars

Treatments	Cultivar				Mean
	Baggi (C_1)	Indira (C_2)	Red Gold (C_3)	Shymal (C_4)	
Gibberellic acid 100 ppm (T_1)	2868.300	3228.300	2955.700	2483.400	2883.925
Gibberellic acid 150 ppm (T_2)	3042.500	3377.300	3183.400	2646.300	3062.375
Salicylic acid 50 ppm (T_3)	2721.800	3152.500	2857.300	2359.500	2772.775
Salicylic acid 100 ppm (T_4)	2933.400	3347.300	3088.300	2566.200	2983.800
Triacontanol 1 ppm (T_5)	2289.300	2685.500	2417.300	1838.400	2307.625
Triacontanol 2 ppm (T_6)	2240.200	2611.400	2353.300	1821.700	2256.650
Triacontanol 3 ppm (T_7)	2464.300	2988.700	2680.400	2141.900	2568.825
Brassinolide 0.1 ppm (T_8)	2332.400	2711.300	2445.500	1936.400	2356.400
Brassinolide 0.2 ppm (T_9)	2570.900	3116.500	2680.500	2240.800	2652.175
Brassinolide 0.3 ppm (T_{10})	2772.300	3219.400	2938.300	2410.800	2835.200
Control (Water spray) (T_{11})	2370.400	2921.700	2626.800	2063.300	2495.550
Mean	2600.527	3032.718	2747.891	2228.464	

	C**	T**	C at T**	T at C**
SEd	5.267	8.253	16.600	16.506
CD (5 %)	16.761	16.680	35.483	33.361
CD (1 %)	30.767	22.320	50.126	44.640

* is measured in terms of unoxidised IAA

** Highly significant

Table 23. Effect of Gibberellic acid and certain other chemicals on IAA oxidase activity* ($\mu g\ g^{-1}h^{-1}$) at peak-flowering stage in Chrysanthemum cultivars

Treatments	Cultivar				Mean
	Baggi (C_1)	Indira (C_2)	Red Gold (C_3)	Shymal (C_4)	
Gibberellic acid 100 ppm (T_1)	3207.300	3517.900	3365.500	2886.600	3244.325
Gibberellic acid 150 ppm (T_2)	3419.400	3593.400	3581.900	3166.800	3440.375
Salicylic acid 50 ppm (T_3)	3066.300	3442.900	3174.700	2766.700	3112.650
Salicylic acid 100 ppm (T_4)	3235.300	3555.400	3432.400	3087.900	3327.725
Triacontanol 1 ppm (T_5)	2630.300	2819.800	2710.400	2209.300	2592.450
Triacontanol 2 ppm (T_6)	2524.800	2767.800	2679.900	2136.300	2527.075
Triacontanol 3 ppm (T_7)	2828.700	3183.400	2867.500	2471.400	2837.750
Brassinolide 0.1 ppm (T_8)	2685.500	3067.900	2749.000	2262.200	2691.150
Brassinolide 0.2 ppm (T_9)	2879.200	3322.300	2867.500	2718.700	2946.925
Brassinolide 0.3 ppm (T_{10})	3122.900	3488.200	3327.300	2833.900	3193.075
Control (Water spray) (T_{11})	2780.400	3158.500	2817.700	2431.200	2796.950
Mean	2943.636	3265.182	3052.164	2633.727	

	C**	T**	C at T**	T at C**
SEd	4.470	9.006	17.747	18.013
CD (5 %)	14.225	18.203	37.176	36.406
CD (1 %)	26.111	24.358	51.528	48.716

* is measured in terms of un oxidised IAA

** Highly significant

4.3.3. Total phenol content (mg/g) in leaves (Table 24)

In general the total phenol content in the leaves was increased by the treatments with growth substances. The results indicated that the highest value of 19.235 was recorded by Baggi and the lowest by Red Gold (7.359). The chemical treatments were highly significant with the highest value for SA 100 ppm (19.578). The lowest value of 9.709 was exhibited by BR 0.1 ppm compared the control (water spray) (11.896) which was on par with BR 0.3 ppm (11.772).

Among the interactions, the highest value of 26.425 was recorded by Baggi + SA 100 ppm followed by Baggi + TR 1 ppm (25.025).

4.4. Post harvest parameters

4.4.1. Vase life (Table 25; Figure 8)

The vase life was highly significant with respect to the cultivar (C), growth substances (G) and holding solution (H). While the interactions, cultivar x growth substance and cultivar x growth substance x holding solution were non-significant. Whereas growth substance x holding solution and cultivar x holding solution gave highly significant results.

Among the cultivars, Indira recorded the longest vase life (15.13 days) followed by Red Gold (14.77 days). Baggi recorded the least period (9.60 days).

Table 24. Effect of Gibberellic acid and certain other chemicals on total phenol content (mg g^{-1}) at peak-flowering stage in Chrysanthemum cultivars

Treatments	Cultivar				Mean
	Baggi (C_1)	Indira (C_2)	Red Gold (C_3)	Shymal (C_4)	
Gibberellic acid 100 ppm (T_1)	21.513	14.713	7.110	15.638	14.743
Gibberellic acid 150 ppm (T_2)	23.563	16.550	9.525	17.688	16.831
Salicylic acid 50 ppm (T_3)	22.263	15.200	9.333	17.413	16.052
Salicylic acid 100 ppm (T_4)	26.425	20.863	11.638	19.388	19.578
Triacontanol 1 ppm (T_5)	25.025	18.588	10.700	18.100	18.103
Triacontanol 2 ppm (T_6)	20.200	14.375	6.525	15.288	14.100
Triacontanol 3 ppm (T_7)	18.850	13.380	5.810	14.760	13.203
Brassinolide 0.1 ppm (T_8)	12.088	10.888	3.663	12.200	9.709
Brassinolide 0.2 ppm (T_9)	12.613	11.038	4.138	12.663	10.113
Brassinolide 0.3 ppm (T_{10})	15.338	12.438	5.400	13.913	11.772
Control (Water spray) (T_{11})	13.713	11.125	7.110	15.638	11.900
Mean	19.235	14.469	7.360	15.700	

	C**	T**	C at T**	T at C**
SEd	0.059	0.129	0.254	0.259
CD (5 %)	0.189	0.261	0.528	0.522
CD (1 %)	0.346	0.350	0.729	0.699

** Highly significant

Table 25. Effect of Gibberellic acid and certain other chemicals on vase life (in days) in Chrysanthemum cultivars

Treat-ment	BAGGI				Mean	INDRA				Mean	RED GOLD				Mean	SHYMAL				Mean
	H_1	H_2	H_3	H_4		H_1	H_2	H_3	H_4		H_1	H_2	H_3	H_4		H_1	H_2	H_3	H_4	
T_1	6.2	7.7	8.8	8.9	7.9	12.4	13.3	13.6	14.1	13.4	12.3	12.6	13.2	13.8	12.9	11.1	11.5	12.5	12.9	12.0
T_2	8.8	9.9	11.2	11.4	10.3	14.7	15.7	16.1	16.8	15.8	14.6	15.3	15.7	16.4	15.5	13.5	13.9	14.9	15.2	14.3
T_3	8.4	9.6	10.8	10.9	9.9	14.3	15.4	15.8	16.3	15.4	14.2	14.9	15.3	16.0	15.1	13.2	13.6	14.5	14.9	14.0
T_4	10.0	10.9	12.3	12.9	11.5	15.9	16.8	17.3	18.4	17.0	15.8	16.3	16.7	17.6	16.6	14.6	15.0	16.1	16.4	15.5
T_5	7.7	8.9	10.1	10.0	9.1	13.6	14.8	15.0	15.5	14.7	13.6	14.2	14.6	15.2	14.4	12.6	13.0	13.8	14.2	13.4
T_6	9.5	10.5	11.9	12.3	11.0	15.5	16.3	17.0	17.7	16.6	15.4	16.0	16.3	17.1	16.2	14.2	14.7	15.7	15.9	15.1
T_7	8.1	9.2	10.5	10.6	9.6	13.9	15.1	15.4	15.9	15.0	13.9	14.5	14.9	15.6	14.7	12.9	13.3	14.2	14.6	13.7
T_8	6.6	7.9	9.1	9.2	8.2	12.7	13.8	13.9	14.4	13.7	12.7	12.9	13.5	14.1	13.3	11.5	11.9	12.8	13.2	12.3
T_9	7.3	8.5	9.6	9.6	8.7	13.3	14.5	14.7	14.6	14.2	13.3	13.8	14.3	14.8	14.0	12.3	12.7	13.4	13.8	13.0
T_{10}	9.0	10.2	11.6	11.9	10.6	15.0	16.0	16.6	17.2	16.2	15.1	15.7	16.0	16.8	15.9	13.8	14.2	15.2	15.6	14.7
T_{11}	7.0	8.1	9.3	9.4	8.4	13.0	14.1	14.4	14.8	14.0	13.0	13.3	13.9	14.5	13.6	11.5	11.9	12.8	13.2	12.3
Mean	8.05	9.21	10.4	10.6		14.0	15.0	15.4	16.0		14.0	14.5	15.0	15.6		12.8	13.2	14.1	14.5	

Table 25. Contd.,

Mean value (Cultivar)	BAGGI	INDRA	RED GOLD	SHYMAL
	9.60	15.13	14.77	13.70

Mean value (Holding solution)	Plain water (H_1)	Sucrose (2 %) (H_2)	Sucrose (2 %) + Aluminium Sulphate (0.2%) (H_3)	Sucrose (2 %) + Silver Nitrate (0.2%) (H_4)
	12.23	13.01	13.76	14.19

Mean value (Growth regulator)	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	T_{11}
	11.56	14.01	13.63	15.18	12.93	14.75	13.29	11.89	12.53	14.36	12.13

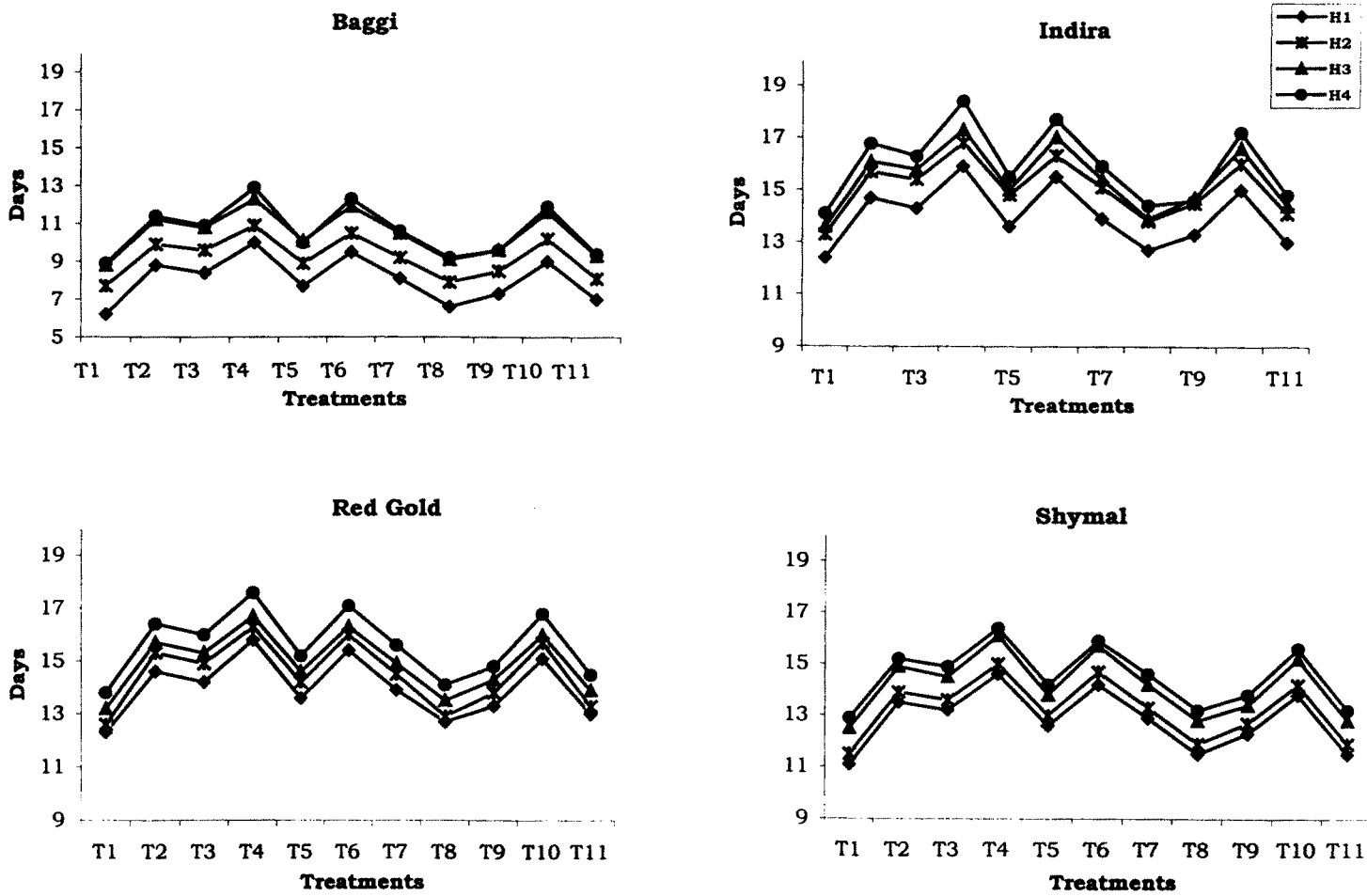
	C**	G**	H**	CG	GH**	CH*	CGH
SEd	0.03	0.42	0.03	NS	0.09	0.05	NS
CD (5 %)	0.05	0.08	0.05	NS	0.17	0.10	NS
CD (1 %)	0.07	0.11	0.07	NS	0.22	0.13	NS

** Highly significant

* Significant

NS Non significant

Fig. 8. Effect of Gibberellic acid and certain other chemicals on vase life (days) in Chrysanthemum cultivars



H1- Plain water
H2- Sucrose 2%
H3- Sucrose 2%+ Aluminium sulphate 0.2%
H4- Sucrose 2%+ Silver nitrate 0.2%

Among the growth substances SA 100 ppm showed the least performance (15.18 days) followed by TR 2 ppm (14.75 days). The others, BR 0.3 ppm (14.37 days), GA_3 150 ppm (14.01 days) also expressed relatively prolonged vase life.

The holding solution sucrose 2% + $AgNO_3$ 0.2% exhibited the best performance (14.19 days) followed by sucrose 2% + $Al_2(SO_4)_3$ (0.2%) (13.76 days). The shortest period was registered in the control (water spray) (12.23 days).

In the interaction between the growth substance and holding solution, SA 100 ppm + sucrose 2% + $AgNO_3$ 0.2% recorded the longest period of 16.31 days. While the least score was from GA_3 100 ppm + control (water spray) with 10.50 days.

The interaction between cultivars and holding solution expressed significant influence on vase life. Indira + sucrose 2% + $AgNO_3$ 0.2% produced the highest score of 15.97 days followed by Red Gold + sucrose 2% + $AgNO_3$ 0.2% (15.63 days). The lowest value was recorded in Baggi + control (water spray) with 8.06 days.

4.5. Correlation and regression studies (Table 26)

Correlation coefficient (r) was worked out between yield and other associated characters such as height of the plant, number of branches, number of suckers, number of days for bud initiation, number of days

for flowering from bud initiation, number of days for 50 per cent flowering, duration of flowering, length of stalk, length of spray, diameter of flower, number of flowers per plant, weight of single flower and weight of hundred flowers.

The results indicated that the yield had significant positive correlation with number of branches (0.577) duration of flowering (0.572) and number of flowers per plant (0.854). And a significant negative correlation with number of days taken for bud initiation (-0.524), number of days for flowering from bud initiation (-0.362), number of days for 50 per cent flowering (-0.423), flower diameter (-0.440) and number of flowers per plant (-0.854) were exerted.

While a non-significant positive correlation was produced for height of the plant, weight of single flower and weight of hundred flowers. And a non-significant negative correlation for number of suckers, spray length and stalk length were recorded.

4.5.1. Intercorrelation between different yield components (Table 26)

i) Height of the plant

Height of the plant was found to possess significant positive correlation with length of the stalk (0.336).

ii) Number of branches

It had significant and positive correlation with duration of flowering (0.618) and number of flowers per plant (0.323). And a

Table 26. Correlation co-efficient of morphological characters with yield in Chrysanthemum cultivars

Parameters	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	Yield
Plant height (X1)	-0.195	0.213	0.085	-0.184	0.241	-0.054	0.233	0.336*	-0.057	0.087	0.225	0.114	0.143
Number of branches per plant (X2)		-0.434**	-0.726**	-0.593**	-0.639**	0.618**	0.227	0.199	0.137	0.323*	-0.046	-0.097	0.364*
Number of suckers per plant (X3)			0.242	0.037	0.327*	-0.289	0.094	-0.056	-0.158	0.041	-0.053	-0.005	-0.072
Number of days to bud initiation (X4)				0.878**	0.874**	-0.949**	-0.449**	-0.342*	0.216	-0.675**	0.415**	0.445**	-0.554**
Number of days from bud initiation to flowering (X5)					0.750**	-0.844**	-0.637**	-0.565**	0.114	-0.581**	0.363*	0.494**	-0.373**
Number of days to 50 % flowering (X6)						-0.851**	-0.467**	-0.315*	0.188	-0.566**	0.525**	0.592**	-0.357*
Duration of flowering (X7)							0.417**	0.325*	-0.312*	0.731**	-0.510**	-0.543**	0.580**
Spray length (X8)								0.853**	0.211	0.057	-0.262	-0.347*	-0.095
Stalk length (X9)									0.381*	-0.110	-0.048	-0.172	-0.183
Flower diameter (X10)										-0.728**	0.527**	0.509**	-0.466**
Number of flowers per plant (X11)											-0.483**	-0.502**	0.817**
Weight of single flower (X12)												0.890**	-0.007
Weight of 100 flower (X13)													-0.008

* Significant at 5 %
** Significant at 1 %

significant negative correlation with number of suckers (-0.434), days for bud initiation (-0.726), days for bud initiation to flowering (-0.593) and days for 50 per cent flowering (-0.639).

iii) Number of suckers

It had significant and positive correlation with days for 50 per cent flowering (0.327).

iv) Days for bud initiation

The days for bud initiation was found to be positive and significantly correlated with days for flowering (0.878), days for 50 per cent flowering (0.874), weight of single flower (0.415) and weight of 100 flowers (0.445) and negative significant correlation with duration of flowering (-0.949), length of spray (-0.449), length of stalk (0.342) and number of flowers / plant (-0.675).

v) Days for 50 per cent flowering

It was observed to be positive and significantly correlated with weight of single flower (0.525) and weight of hundred flowers (0.592). A negative correlation with duration of flowering (-0.851), length of the spray (-0.407), length of the stalk (-0.315) and number of flowers per plant (-0.566).

vi) Duration of flowering

It had significant positive correlation with length of spray (0.417), length of stalk (0.325) and number of flowers per plant (0.731). And

negative significant correlation with diameter of flower (-0.312), weight of single flower (-0.510) and weight of 100 flower (-0.543).

vii) Length of spray

It had positive and significant correlation with length of the stalk (0.853), negative and significant correlation with weight of 100 flowers (-0.347).

viii) Length of stalk

It had significant and positive correlation with flower diameter (0.381).

ix) Diameter of flower

It was positive and significantly correlated with weight of single flower (0.527) and weight of 100 flowers (0.509) and had negative significant correlation with number of flowers per plant (-0.728).

x) Number of flowers per plant

It had negative and significant correlation with weight of single flower (-0.483) and weight of 100 flowers (-0.502).

x) Weight of single flower

It had positive significant correlation with weight of 100 flowers (0.890).

Taking all characters together the multiple correlation was worked out as R = 0.975, which was highly significant. A multiple regression line

was fitted for the yield of flowers with morphological characters. The fitted multiple regression equation is presented below :

Flower yield = -912.34 + 1.391 **X1** + 0.001 **X2** + 4.510 **X3** – 2.532 **X4** + 6.367 **X5** + 0.601 **X6** + 2.495 **X7** + 2.648 **X8** – 1.564 **X9** + 12.695 **X10** + 2.488 **X11** + 57.283 **X12** + 0.061 **X13**.

4.6. Cost economics for cut flower production of Chrysanthemum (Table 27)

In Chrysanthemum, the net income due to the treatments varied from Rs.94,000 per ha for control to Rs.1,66,200 per ha for TR 3 ppm. The cost of cultivation was Rs.50,000 per ha. The highest gross income of Rs.2,20,000 per ha was associated with the plants subjected to treatment with 3 ppm of TR, closely followed by plants treated with TR 2 ppm (Rs.1,86,000/ha) and SA 100 ppm (Rs.1,82,600/ha). The results indicated that adoption of the recommended package of practices coupled with application of TR at 3 ppm concentration resulted in highest net income. The cost benefit ratio for the best treatment TR 3 ppm was 1:4.09 while the lowest (1:2.23) was obtained from GA_3 150 ppm treatment.

Table 27. Cost economics of cultivation for cut flower production of Chrysanthemum cultivars

Treatments	Calculated number of sprays per ha	Calculated additional number of sprays per ha	Per cent increase in number of sprays over control	Quantity of chemicals required per ha	Cost of cultivation (per ha) (Rs)	Gross income per ha (Rs)	Net income per ha (Rs)	Cost Benefit ratio
GA 100 ppm (T_1)	88400	16400	22.78	150 g	69000	176800	107800	1:2.56
GA 150 ppm (T_2)	86100	14100	19.58	225 g	77250	172200	94950	1:2.23
SA 50 ppm (T_3)	90400	18400	25.56	75 g	52540	180800	128260	1:3.44
SA 100 ppm (T4)	91300	19300	26.81	150 g	52580	182600	130020	1:3.47
TR 1 ppm (T5)	84600	12600	17.50	1500 ml	52915	169200	116285	1:3.20
TR 2 ppm (T6)	93100	21100	29.31	3000 ml	53325	186200	132875	1:3.49
TR 3 ppm (T7)	110000	38000	52.77	4500 ml	53740	220000	166260	1:4.09
BR 0.1 ppm (T8)	85500	13500	18.75	150 ml	52845	171000	118155	1:3.24
BR 0.2 ppm (T9)	82700	10700	14.86	300 ml	53190	165400	112210	1:3.11
BR 0.3 ppm (T10)	90400	24400	33.88	450 ml	53535	180800	127265	1:3.38
Control (Water spray) (T11)	72000	-	-	-	50000	144000	94000	1:2.88

Cost of cultivation (excluding chemical cost) – Rs 50,000 per ha

Rates of chemical applied:
Gibberellic acid – Rs 110 / g
Salicyclic acid – Rs 510 / kg
Triacontonal – Rs 55 / 200 ml
Brassinosteroids – Rs 2300 / l

Quantity of the spray solution
500 l/ spray
1500 l for 3 sprays
Cost of 1 flower spray- Rs 2.00

Discussion

Chapter 5

DISCUSSION

Chrysanthemum (*Dendranthema grandiflora* Tzelev.) occupies a leading position in world's cut flower trade. The uses of plant growth regulators have played an impressive role in manipulating the growth, flowering and quality of ornamentals. The growth and development of Chrysanthemum, is largely influenced by environment. Hence, the possibility of year round supply of flowers is explored in Chrysanthemum by use of chemicals. Keeping this in view, the present study was initiated to investigate the effect of GA_3 and certain other chemicals on the improvement of growth, flowering and cut flower production of Chrysanthemum.

Morphological characters

The growth regulating chemicals are known to enhance the value of the crop by increased stem elongation, branching and uninterrupted flowering. Height of the plant which is considered to be one of the contributing factors for flower production was greatly influenced by the chemical treatments. The GA_3 treatments resulted in remarkable height increase in the cultivar Shymal over a period of time. The cultivars Red Gold and Baggi responded well to a lesser extent to these treatment. The finding of Marth *et al.* (1956) who demonstrated that application of GA_3

led to marked stem elongation supports the results of the present investigation. The statement of Krishnamoorthy (1993) that application of GA_3 produces long and wiry stems are also in line with the present study. The observations of Talukdar and Paswan (1996) supports the present results that on spraying with GA_3 40 ppm on Chrysanthemum, a significant increase in height of the plant was obtained. The mechanism involving the conversion of starch to sugar was inferred by analogue with known effects of GA_3 by increase in length. It has been established that the capacity of the cell to respond to GA_3 by undergoing cell division is the function of their state of differentiation. In addition, GA_3 also causes re-orientation of the mitotic spindle, thereby contributing to the length of the stem rather than the girth of it. The present work is also confirmed by the findings of Narayana Gowda (1990) in China aster, Singh *et al.* (1994) in Dahlia and Dutta and Seemanthini (1997) in Chrysanthemum. The shortest plant height was observed on treatment with TR. It could be attributed to the fact that TR raises the peroxidase levels and auxin breakdown, ultimately leading to reduced apical dominance producing short statured plants (Henry and Gordon, 1980).

The interaction effects of Red Gold and GA_3 resulted in the production of more number of branches. These findings corroborate with the statement of Nagarjuna *et al.* (1988) who demonstrated 100 per cent extra primary branches with GA_3 over control. The work of Kulkarni *et al.*

(1997) confirm the present finding, that on treatment with 100 ppm of GA_3 in Chrysanthemum the highest number of primary and secondary branches could be obtained.

The findings of Dutta and Seemanthini (1997) is also in confirmation with the present conclusion, indicating that GA_3 150 ppm recorded the highest number of laterals. Stimulation of branching and production of more number of nodes and leaves may be possibly attributed to the breakage of apical dominance and thereby setting up of auxin balance as well as enhanced differentiation of internodes.

Flower characters

The genotype of the plant and the environment are the primary determinants of the flowering process. Apart from the environmental influence, chemical regulation of flowering also proved to be beneficial from the present study. Early flowering was achieved on treatment with GA_3 in the cultivars Indira and Red Gold, while the cultivar Shymal had the longest period for flowering. On treatment with GA_3, increased photosynthesis and respiration along with enhanced carbon-di-oxide fixation lead to early flowering (Sen and Sen, 1968). These results corroborates the finding of Ramasamy *et al.* (1979) in Tuberose. They reported that GA_3 at 100 ppm advanced the flowering by 17 days over control. Similar views were also expressed by Jana and Biswas (1982) in Tuberose, Jayanthi and Gowda (1991) in China aster, Dutta and

Seemanthini (1997) in Chrysanthemum and Sivakumar (1997) in tuberose. The application of GA_3 also produced longer duration of flowering in the cultivar Red Gold. It was supported by Dutta and Seemanthini (1997) that longest duration of flowering was attained by spraying of GA_3. Moreover an earliness in flowering coupled with extended duration of flowering caused by GA_3 application is in consonance with the results of Sen and Maharana (1971), Shanmugam *et al.* (1973), Nagarjuna *et al.* (1988) and Dutta and Seemanthini (1997) in Chrysanthemum. Advanced bud initiation and onset of flowering in GA_3 treated plants is attributable to extension of growth stimulated by GA_3.

Growth promoting chemicals resulted in stem elongation. From the present investigation, it is clear that GA_3 was solely responsible for an increased length of the stalk and length of the spray. A pronounced length of the stalk and spray was obtained in the cultivar Indira. The other cultivars also showed a positive response to GA_3 treatments. The increase in length of the flower stalk may be due to the rapid elongation of internodes, which was again due to increased cell division and cell enlargement. An enhanced apical dominance led to the production of elongated sprays (Marth *et al.,* 1956). The present work is in confirmation with the findings of Reddy and Sulladmath (1972) in China

aster, Holcomb *et al.* (1991), Kulkarni *et al.* (1997) and Dutta and Seemanthini (1997) in Chrysanthemum.

Verma *et al.* (1997) also demonstrated that among the different cultivars of Chrysanthemum, the cultivar Cotton Ball showed pronounced increase in length of the spray on treatment with GA_3.

BR proved its potential in increasing the diameter of the flower in Chrysanthemum. The cultivars Indira and Shymal responded well to this treatment. The greater flower diameter might be due to the synergism between BR and auxins. The BR might have altered the biophysical properties of plant cell walls and increased the abundance of mRNA transcripts for wall modifying proteins. These properties of BR have led to high energy conversion in broadening the flower diameter (Clousse and Sasse, 1998).

Triacontanol (TR), being a natural plant steroid was found to increase the total number of flowers per plant. Except for the cultivar Red Gold, the other cultivars showed negligible influence to this treatment. The increased number of inflorescence would have been caused by reduced apical dominance resulting from an internal reduction of IAA level. The main effects of TR on Chrysanthemum seem to be related to an increased growth rate, producing larger inflorescence carrying a higher number of flowers (Skogen *et al.*, 1983). From the present investigation, it is evident that a phenolic compound SA is

responsible for the higher weight of flowers. It ultimately leads to a greater yield potential of the crop. The favourable effects of SA could be due to synergistic between IAA and phenolics. This effect was not only from the acceleration in the initiation of flower buds but also by the enhanced number of flower buds.

The cultivar Shymal on treatment with SA recorded greater weight of the flowers. Whereas Red Gold registered the highest yield which might be due to higher number of flowers per plant. The reports on florigenic effects of exogenous SA was demonstrated in *Oncidium*, *Impatiens* and *Spirodela punctata* (Raskin, 1992). The results of the present study is in agreement with the earlier work of Ramesh (1999) in China aster with the increased weight of 100 flowers and overall yield increase of the crop.

Physiochemical parameters

Chlorophyll is an important pigment involved in photosynthesis was found to be greatly influenced by growth promoting chemicals, BR treatment in the cultivar Baggi exhibited an increasing trend of chlorophyll a, b and total chlorophyll, content in the vegetative stages. The inferences suggest a possible mobilization role of BR and establish the importance of adequate photosynthate. Similar line of work have been reported by Sairam (1994) and Bhatia and Kaur (1997). Whereas, Murali and Gowda (1988) in Jasmine and Nagarajaiah and Reddy (1986)

in Rose observed a decrease in chlorophyll content on treatment with GA_3.

IAA oxidase is the enzyme which is responsible for the degradation of auxin was influenced by the chemical treatments. The IAA oxidase was suppressed at various concentrations of growth promoting chemicals, *viz.*, BR, SA and GA_3. Thus the treatments increased the auxin content significantly from vegetative to flowering stages. From the present study, GA_3 was found to reduce the IAA oxidase activity effectively. The increase in activity of IAA-oxidase in the leaves of *Impatiens balsamina* receiving GA_3 treatment suggested the floral induction in the treated plants (Kamlesh and Nanda, 1986).

The total phenol content is an important source of resistance in plants. The present study indicates that the treatment of SA raised the phenol content in Baggi. It could be attributed to the fact that SA induces resistance to pathogen by production of PR proteins (Plant Resistance Proteins) (Raskin, 1992). Moreover SA was found to be an endogenous messenger that activates important elements of host resistance to pathogens. Similar line of observations were made in Marigold where an increased phenol content led to increased biosynthesis of lignin. It ultimately increases the host resistance (Shyam *et al.*, 1994). The earlier work carried out by Schlosser (1994) supported the present findings, that proanthocyanidin (a pre-formed phenol)

governs the differential resistance of *Cyclamen persicum* to the pathogen *Botrytis cinerea.* Moreover, SA is an endogenous messenger that activates important elements of host resistance to pathogens.

Post harvest characters

The use of flower preservatives to promote the quality and to prolong the life of cut flowers has been known since many years. The termination of vase life of many cut flowers characterized by wilting and therefore, many studies have been made at evaluation of events leading to this phenomenon (Halevy and Mayak, 1981). There has been much progress in recent years on understanding the factors affecting flower senescence. Some considerable advances have been made as a result of experimentation with plant growth substances and plant growth regulators and this had benefit at strategic and practical levels.

There is sufficient evidence to suggest that the biosynthetic pathway of ACC production in flowers is probably similar to that in other plant organs which have been investigated. The involvement of ethylene in such a phenomenon is well recognized but it had the possible role of auxins in pollination which first drew the attention of the scientists to the functions of growth substances in flower senescence.

The present study unravels the fact that pre harvest spray of SA 100 ppm resulted in the prolonged vase life of Chrysanthemum. The

contribution of this chemical was more pronounced in the cultivars Indira, closely followed by Red Gold.

Indications of the mechanisms by which SA may increase flower longevity can be found after the discovery that SA inhibits ethylene biosynthesis by blocking the conversion of 1-aminocyclopropane-1-carboxylic acid (ACC) to ethylene. Among 22 related phenolic compounds tested, only asprin showed levels of inhibition similar to that of SA. Moreover, the iron chelating property of SA could, however, explain the inhibitory effect of SA on ethylene – forming enzyme, because iron is an essential factor for the conversion of ACC to ethylene (Raskin, 1992).

Among the different preservatives tried, the combination of sucrose (2%) + silver nitrate (0.2%) enhanced the vase life of cut flowers than sucrose alone. It is in confirmation with the works of Kushal *et al.* (1997) that holding solution of sucrose 5% + $AgNO_3$ 25 ppm + citric acid 75 ppm substantially extended the vase life of Chrysanthemum flowers. Sucrose concentration influences fluid uptake and transpiration in cut flowers. Sucrose or preservatives containing carbohydrate substrate for the naturally depleting carbohydrates in cut flowers, reduced proteolysis. Coorts *et al.* (1965) reported that sucrose sustained quality, enhanced weight and prolonged cut flower life.

One of the important problems encountered with vase life of cut flowers is the growth of microorganisms. In order to inhibit microbial

growth, a suitable bactericide ought to be present in the holding solution. Silver ions in spite of its activity as a bactericide, is said to inhibit the production of ethylene. It has been reported in many crops such as Chrysanthemum, Gladiolus, Gerbera, China aster, *etc.* Hence, the silver nitrate acted both as disinfectant and anti senescence chemical.

Correlation and regression studies

Correlation coefficient was worked out between yield and related morphological characters in order to understand the nature and association with yield and also their inter associations. It is obviously apparent that yield is governed by both genotype and environment. Any modification in the characters attributing to yield brings about considerable alterations on the yield of the crop. Hence, it is imperative to study the association of different plant characters with yield and also their interactions so that desirable effects could be achieved.

In the present study, yield exhibited significant and positive correlation with number of branches, duration of flowering and number of flowers per plant. These results are in consonance with earlier findings of Bhanu Pratap *et al.* (1999) in Marigold and Janakiram and Rao (1994) in China aster for the character number of flowers per plant. The results are also corroborated with the findings of Chattopadhyay *et al.* (1992) and Sirohi and Behera (1999) for the characters number of flowers per plant and number of branches per plant in Chrysanthemum. Correlation

studies in Zinnia by Jhon *et al.* (1994) showed that number of branches per plant expressed significant positive correlation with number of flowers.

Significant negative correlation were exerted between days for bud initiation, days for flowering from bud initiation, days for 50 per cent flowering, diameter of the flower and yield. It suggests that early flowering types result in higher yield. Similarly increased diameter of the flower results in accelerated translocation of photosynthates to individual flowers thereby reducing the total number of flowers produced.

Inter correlation among different yield components

The height of the plant expressed a significant and positive correlation with length of the stalk. This is in accordance with reports of Ashwath and Parthasarathy (1994) for length of the spike and length of rachis in gladiolus. Further the total number of branches was found to be positive and significantly correlated with number of flowers per plants. This was in agreement with the reports of Jhon *et al.* (1994) who recorded in *Zinnia,* that there was a positive significant correlation between number of branches and flowers per plant, indicating that an increase in branch number ultimately results in an increased production of flowers. Similar views were reported by Bhanu Pratap *et al.* (1999) in Marigold and Sirohi and Behera (1999) in Chrysanthemum.

The characters days for bud initiation, days for bud initiation to flowering and days for 50 per cent flowering were positive and significantly correlated with weight of single flower and 100 flower weight. While the same characters were negative and significantly correlated with duration of flowering, length of spray, length of stalk and number of flowers. In Marigold, Bhanu Pratap *et al.* (1999) observed a negative, non-significant association between the characters visibility of bud, days from just bud appearance to opening of marketable flower and duration of flowering. Similar inferences were reported in Chrysanthemum by Sirohi and Behera (1999) for the character days for first bud initiation and days to first flower opening.

Duration of flowering exerted positive and significant correlation with length of the spray, length of the stalk and number of flowers. Number of flowers showed a negative and significant correlation with weight of flowers.

Practical utility of the findings

The present study on the effect of Gibberellic acid and certain other chemicals on the cut flower production of Chrysanthemum has indicated that among the four chemicals, *viz.*, GA_3, SA, TR and BR tried at various concentrations, spraying of TR at 3 ppm resulted in highest spray production per ha (1,10,000 sprays/ha) which was significantly superior than the untreated control (72,000 sprays/ha) with the cost of

cultivation of Rs. 50,00/ha. Generally, an increased spray production was achieved on treatment with all the four chemicals compared to control. The cost of these chemicals varied from Rs.24,525 in the case of 150 ppm of GA_3 to Rs.38.40 in the case of 50 ppm of SA. In the case of GA_3 treatment, though the spray production was improved, due to its higher cost, the net income got reduced considerably. While the net income and cost benefit ratio on treatment with TR 3 ppm was the highest compared to the control (water spray). Though SA was eminent in producing higher yields, with reference to cut flower production GA_3 treatment proved to be the best. The GA_3 improved the quality by producing long stemmed flowers. Improvement in stem length will enhance the pricing for individual flower stems in the international market, because length of the stem ultimately decides the price in the market.

Summary

Chapter 6

SUMMARY

Studies were conducted on the effect of Gibberellic acid and certain other chemicals to explore the possibilities on cut flower production in four cultivars of Chrysanthemum (*Dendranthema grandiflora* Tzelev.) during 1999-2000 at the Botanical Gardens, Department of Floriculture and Landscaping, Horticultural College and Research Institute, TNAU, Coimbatore. The following are the salient findings of the present investigation.

1. Height of the plant increased as the age of the crop advanced irrespective of the treatments. The cultivar Shymal recorded the highest plant height (67.88 cm) on treatment with GA_3 150 ppm at 120 days after planting.

2. The cultivar Red Gold on treatment with GA_3 150 ppm resulted in the production of the highest number of branches (15.75), while the sucker production was increased by SA at 100 ppm.

3. In general, treatment with GA_3 recorded early flowering. The cultivars Indira and Red Gold took lesser period for flowering on treatment with GA_3 at 150 ppm (50 days) compared to control (65.13 days).

4. The longest duration of flowering (76.50 days) was obtained from the cultivar Red Gold on treatment with GA_3 100 ppm.

5. Length of flower stalk and length of spray were significantly increased by the application of GA_3 and other chemicals compared to control. The concentration of GA_3 150 ppm recorded the greater increase in the length of the stalk (35.91 cm).

6. Brassinolide (BR) application was found to increase the diameter of the flower. The treatment of BR at 0.2 ppm resulted in the highest diameter of the flower (7.88 cm) in the cultivar Indira.

7. The number of flowers per plant was the highest in the cultivar Red Gold with TR 3 ppm (139.10) than any other treatments.

8. Salicylic acid (SA), a phenolic substance, in general, increased the weight of the flowers at a concentration of 50 and 100 ppm. The total yield per plant (248.09 g) and calculated yield per ha (27564.97 kg) was enhanced by the treatment of SA at 100 ppm in the cultivar Red Gold.

9. Chlorophyll 'a', chlorophyll 'b' and total chlorophyll were significantly raised in cultivar Baggi by BR 0.5 ppm sprays (1.416, 0.511 and 1.582 mg/g), respectively.

10. The unoxidised IAA was increased by GA 150 ppm in Indira from pre-flowering stage (3032.72 µg/g/h) to peak-flowering stages (3265.18 µg/g/h).

11. The treatment with SA 100 ppm exhibited the highest total phenol content (26.425 µg/g) in the cultivar Baggi.

12. The vase life of cut flowers was extended significantly by pre-harvest spray of SA. Among the preservatives tested, silver nitrate (0.2%) in association with sucrose (2%) enhanced the overall vase life. The cultivar Indira registered a longest vase life (15.63 days) in combination with SA 100 ppm + sucrose (2%) + silver nitrate (0.2%).

13. Correlation studies indicated that yield had positive significant correlation with number of branches (0.577), duration of flowering (0.572) and number of flower per plant (0.854)

14. A negative significant correlation with number of days taken for bud initiation (-0.524), number of days for flowering from bud initiation (-0.362), number of days for 50 per cent flowering (-0.423), diameter of the flower (-0.440) and number of flowers per plant (-0.854) was obtained.

15. Spraying of TR at 50 ppm increased the gross income per ha (Rs.2,20,000) compared to control (Rs.1,44,000) with the cost of cultivation of Rs.50,000 per ha. It also increased the net income per ha (Rs.1,66,260) and the cost benefit ratio (1:4.09).

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* Originals not seen.

Appendix

ANNEXURE – I

Chemical	Cost	Source
GA_3	1g – Rs.109.00	SD fine chemicals Limited, No.5,GNT Road, Moolakkodai, Chennai – 600 110.
SA	1Kg – Rs. 510.00	SD fine chemicals Limited, No.5,GNT Road, Moolakkodai, Chennai – 600 110.
TR	200ml – Rs.55.00	Bahar Agrochem. And Feeds Private Limited, E – 24, MIDC,Lote, Parashuram,Khed, Ratnagiri, Maharastra.
BR	1l – Rs.2300.00	Godrej Agro-vet, Bangalore.

ANNEXURE - II

WEATHER DATA WEEKLY WISE AT THE TIME OF CROP DURATION

Month/Weekiky	MAX TEMP(C^0)	MIN TEMP(C^0)	RH(%) 7.22 hr	RH(%) 14.22 hr	RAIN FALL (mm)
1999 JULY					
1	30.1	22.6	77	51	10
2	32.9	20.8	87	41	-
3	32.6	20.8	86	49	-
4	32.6	22.4	83	49	1.0
5	31.9	22.4	79	69	21
6 AUGUST	28.3	23.3	74	56	3.8
7	29.5	23.2	71	49	3.0
8	30.9	23.01	81	55	0.2
9	31.2	22.3	87	50	18.7
10	32.7	21.8	88	52	-
11 SEPTEMBER	32.0	21.9	85	46	-
12	32.2	22.3	78	43	-
13	32.3	21.4	83	43	-
14	33.0	22.4	89	50	28.0
15	33.7	22.9	91	46	72.3
16 OCTOBER	33.5	22.5	94	68	31.9
17	29.9	22.3	93	60	155.4
18	30.9	21.9	95	74	44.5
19	29.5	22.5	94	65	2.0
20 NOVEMBER	29.8	20.2	94	64	64.2
21	30.2	19.8	91	51	-
22	29.9	18.4	88	47	35.0
23	29.7	21.0	93	71	6.4
24	28.4	19.1	91	63	-
25 DECEMBER	28.3	19.3	91	59	3.0
26	26.2	18.3	91	62	10.0
27	27.9	19.3	88	57	8.8
28	26.8	19.9	90	54	-

Plates

Plate 1. Field View of Chrysanthemum cultivars

1a. Vegetative Stage

1b. Flowering Stage

Plate 2. Selected Chrysanthemum cut flower cultivars subjected to chemical regulation

BAGGI

INDIRA

RED GOLD

SHYMAL

Plate 3. Effect of GA_3 150 ppm on height of the plant at 60 days after transplanting in Chrysanthemum cultivars

BAGGI **RED GOLD** **INDIRA** **SHYMAL**

Plate 4a. Effect of GA_3 and certain other chemicals on length of the spray in Chrysanthemum cultivars

T2 T10 T4 T11

T2 T10 T4 T11

Plate 4b. Effect of GA_3 and certain other chemicals on length of the spray in Chrysanthemum cultivars

T2 T10 T4 T11

T2 T10 T4 T11

Plate 5. Effect of GA_3 and certain other chemicals on diameter of the flower in Chrysanthemum cultivars

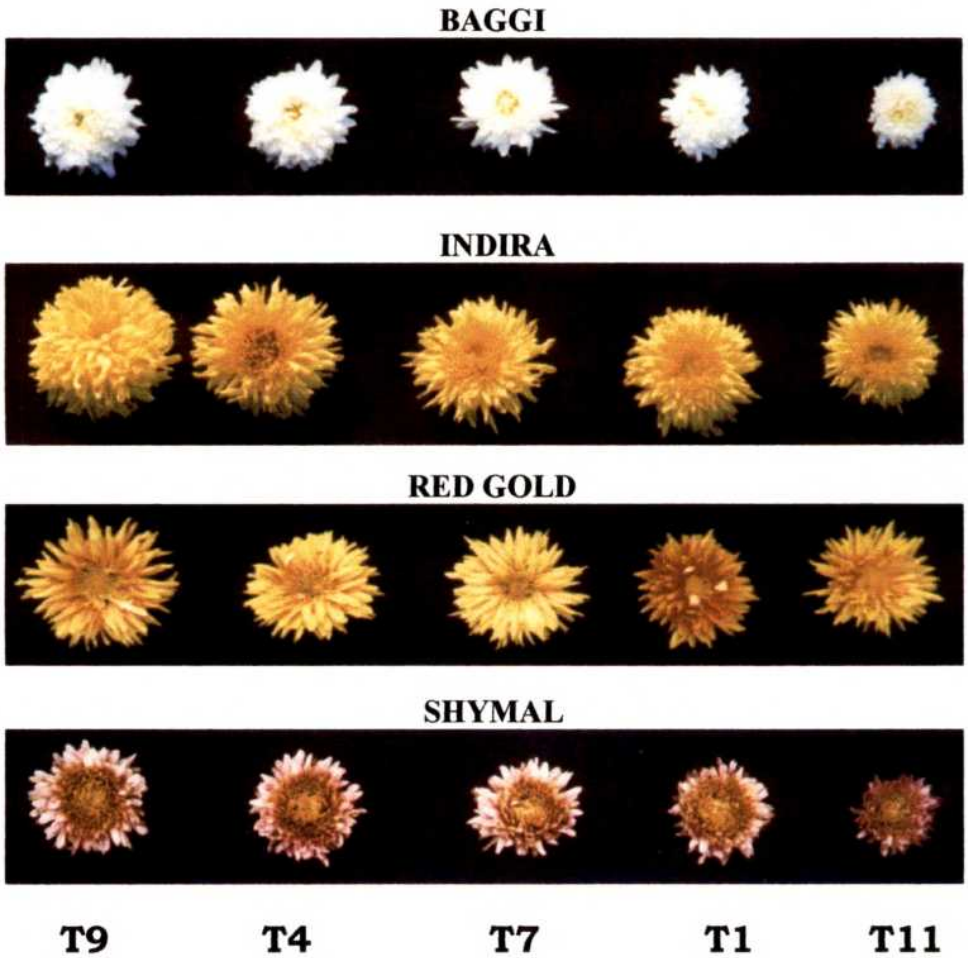
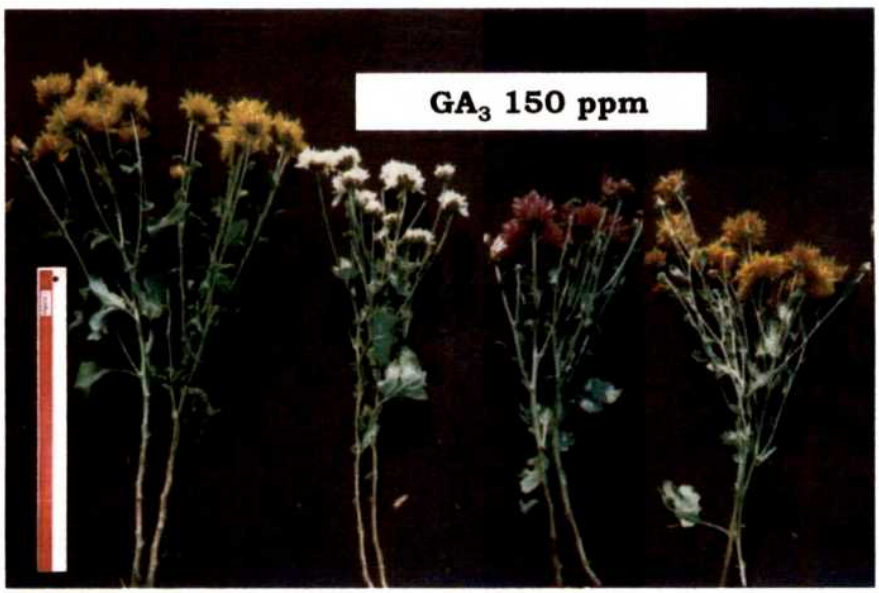
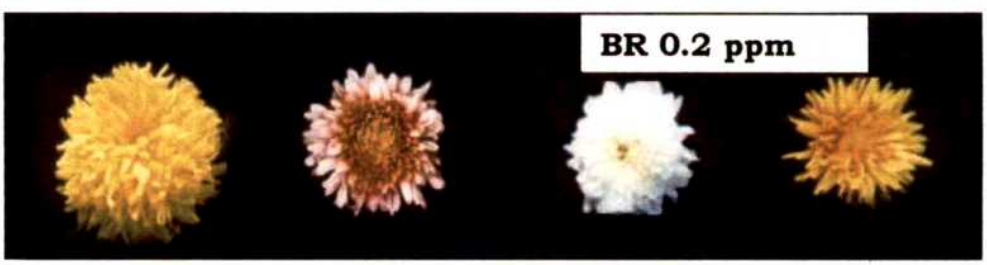


Plate 6.Variation among Chrysanthemum cultivars for length of the spray as influenced by GA_3 150 ppm



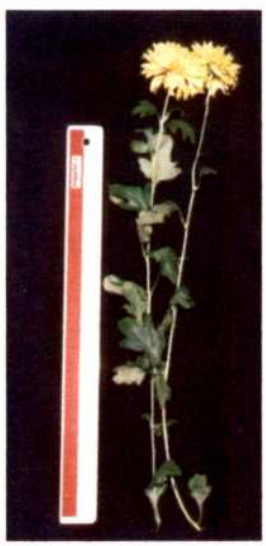
Indira Baggi Shymal Red Gold

Plate 7. Variation among Chrysanthemum cultivars for diameter of the flower as influenced by BR 0.2 ppm



Indira Shymal Baggi Red Gold

Plate 8. Indira as a superior performing cultivar for cut flower production



- **Stalk length - 35.91 cm**
- **Early flowering - 111.88 days ($GA_3$100 ppm)**
- **Flower diameter -7.88 cm (BR 0.2 ppm)**
- **Vase life - 15.97 days (Salicylic acid 100 ppm)**