INFLUENCE OF PINCHING AND FOLIAR APPLICATION OF GROWTH CHEMICALS ON GROWTH AND YIELD OF CHRYSANTHEMUM

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CERTIFICATE

This is to certify that the thesis entitled **"Influence of Pinching and Foliar Application of Growth Chemicals on Growth and Yield of Chrysanthemum"** submitted to the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in HORTICULTURE**, embodies the result of a piece of bona fide research work carried out by **Sultana Umma Habiba**, Registration No.**04-01265** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information, received during the course of this investigation has been duly acknowledged.

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INFLUENCE OF PINCHING AND FOLIAR APPLICATION OF GROWTH CHEMICALS ON GROWTH AND YIELD OF CHRYSANTHEMUM

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ABSTRACT

An experiment was conducted at Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka during the period from October 2008 to March 2009. The experiment consisted with two factors; Factor A: pinching viz. P_0: without pinching and P_1: with pinching and Factor B: foliar application of growth chemicals viz. F_0: control, F_1: Wuxol; F_2: Vegimax, F_3: Agro grow and F_4: Surgrow with 3 replications. In case of pinching the tallest plant (37.7 cm), was recorded from P_0 but maximum number of leaves per plant (30.1) and flowers (58.7) per plant was recorded from P_1 and the shortest plant (33.4 cm) was recorded from P_1 but minimum number of leaves (26.8), and flowers per plant (37.9) was recorded from P_0. For foliar application of growth chemicals the tallest plant (38.2 cm), maximum number of leaves per plant (31.6), maximum number of flowers (58.6) was recorded from F_2 and the shortest plant (31.4cm), minimum number of leaves (21.3) and flowers per plant (32.1) was recorded from F_0. In case of combined effect the maximum number of leaves per plant (33.6), maximum number of flowers (83.3) was recorded from P_1F_2 and all the above parameters were lowest with P_0F_0. So, pinching with vegimax was found suitable for growth and yield of chrysanthemum.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

DEDICATED
TO
MY BELOVED
PARENTS

ABBREVIATIONS AND ACRONYMS

AEZ	=	Agro-Ecological Zone
ANOVA	=	Analysis of Variance
cm	=	Centimeter
CRD	=	Completely Randomized Design
cv.	=	Cultivar
DAT	=	Days after Transplanting
Dept.	=	Department
DMRT	=	Duncan's Multiple Range Test
et al.	=	And others
Hort.	=	Horticulture
i.e.	=	That is
J.	=	Journal
K	=	Potassium
L	=	Litre
LSD	=	Least Significant Difference
ml	=	Mililitre
N	=	Nitrogen
P	=	Phosphorus
PHT	=	Postharvest Technology
Res.	=	Research
RH	=	Relative Humidity
SAU	=	Sher-e-Bangla Agricultural University
Sci.	=	Science
Viz.	=	Namely
%	=	Percentage
@	=	At the rate of
^{0}C	=	Degree Celsius

CHAPTER I

INTRODUCTION

Chrysanthemum (*Chrysanthemum* sp) is a popular flower belongs to the family Asteraceae of about 100 to 200 species. It is native to the northern hemisphere chiefly Europe and Asia with a few in other areas. Many authorities claim that it originated in China (Carter, 1980). Chrysanthemum, commonly known as the mum flower, is one of the most popular decorative flowers of fall and winter, both with florists and home gardeners. There are several reasons, among them the fact that these flowers have a long life as cut flowers, lasting up to two weeks in the vase and the many colors appropriate to fall decorating schemes. The mum flower is well-loved by the home gardener, bringing a bright display of colors when most other flowers are long gone.

In recent years, demand for pot plants for house decoration and for use in amenity horticulture has steadily increased not only for their outstanding aesthetic beauty and a long lasting quality but also because of their good prospect of marketing as cut flowers and potted plants to many countries in the world (Erler and Siegmund, 1986). Chrysanthemum has been considered as number one among the major pot flowers (Carter, 1980). Chrysanthemum blooms are composed of many individual flowers (florets), each one capable of producing a seed. Gardeners like to grow chrysanthemums because of their variety of size, shape and color. They are very popular in floral bouquets and flower arrangements.

Plant breeder have done a wonderful job of developing outstanding flower colors, including white, cream, shades of yellow, from light and pale to bright and deep gold, a rusty red, deep red and even pink and light purples. A large number of chrysanthemum cultivars, are the result of conscious or unconscious selection by growers and breeders over the centuries. About one third of commercial cultivars of chrysanthemum have arisen as spores or somatic mutants as a result of loss or gain of chromosomal material during mitosis (Dowrick and El-Bayoumi, 1966).

The climatic condition of Bangladesh is well adapted for cultivation of chrysanthemum but the commercial production of chrysanthemum in Bangladesh is very low. Chrysanthemum has a shallow but fibrous root system which is sensitive to water logging and prone to attack by diseases. Sandy loams retain sufficient moisture and provide optimum aeration which is ideal for chrysanthemum growing. In general it requires high light intensity and plants grown under reduced light become taller have strong stem and larger leaves. Pot-mum production has become the most profitable form of commercial chrysanthemum due to economy of space, time and materials. Bangladesh has a capable of producing a wide variety of commercial chrysanthemum.

Pinching is simply means removing the terminal growing portion of stem. It is practiced to induce branching and reduce the plant height. Pinching makes chrysanthemums yields compact, bushy plants with more blooms and also helps in breaking the rosette and also improve the plant's looks. The plant height, stem diameter and number of inflorescences increased as the number of pruning’s (Brum *et al*., 2007). Linear increase in yield was recorded as the pinching severity increased. Double pinched plants were superior and recorded more yield per plant in chtysanthemum (Chavan *et al*., 2004).

Application of certain nutrient and growth hormone as foliar feeding has been found to influence the growth and flowering of chrysanthemum. Those are used as

foliar feeding in chrysanthemums because foliar application is more efficient due to higher percentage of nutrient is absorbed by plants which influences the growth and development of chrysanthemums and improve the quality of flowering. Foliar feeding reduces the cost of production which encourages the commercial growers for its commercial production. It contents a great demand in all global regions.
Pinching and foliar feeding enhanced the production of quality cut flower. Only top-quality flowers are traded internationally because of the increasing quality-consciousness of the customers. Success of chrysanthemum in the market place will depend ultimately on the sincerity of the grower to pursue retail and wholesale floral markets. Quality must be demonstrated and price set to undersell the competition. Retailing through "pick-your-own" farm stands and farmers markets may be the best ways for the small grower to become familiar with growing the crop, developing a quality product, and establishing a good reputation in the market. This research work helps the commercial gardeners to increase the number and size of flowers. It also helps to the gardeners to improve the quality and color of the chrysanthemum flower.

In Bangladesh, only limited studies have been done regarding pinching and use of foliar feeding for growth, yield and color of chrysanthemums. Therefore, the research work so far done in Bangladesh is not adequate and conclusive. Considering the above facts, the present study was undertaken with following objectives-

- To study the effect of pinching on growth, coloration and yield of chrysanthemum and
- To determine the effect of different foliar application of growth chemicals on growth and yield of chrysanthemum

CHAPTER II

REVIEW OF LITERATURE

Chrysanthemum is one of the most important and popular decorative flower in Bangladesh as well as many countries of the world. As an ornamental flower this has conventional less concentration by the researchers on various aspects because it is small in size and not very familiar with the common people of our country in relation with outstanding aesthetic beauty and a long lasting quality. For that a very few studies on the growth and coloration of chrysanthemum have been carried out in our country as well as many other countries of the world in relation with pinching and foliar application for chrysanthemum production. Some of the important informative works and research findings related to pinching and foliar application on growth and coloration of chrysanthemum so far been done at home and abroad have been reviewed in this chapter under the following headings:

2.1 Pinching on flowering plant

A greenhouse experiments were conducted by Brum *et al*. (2007) to evaluate the vegetative and reproductive behaviors and the length of growing stage of 2 chrysanthemum cultivars (Veria Dark and Papiro) under protected environment and submitted to different number of prunings and pot sizes. Regarding the inflorescence production, the numbers of prunings for each pot size and chrysanthemum cultivar were used as treatments. Plant height, stem diameter and number of inflorescences increased as the number of prunings than the control condition. However, stem diameter decreased in both cultivars. The cultivar Veria Dark was less responsive than the cultivar Papiro.

Rooted cuttings of carnation cv. 'Sunrise' were planted on four dates with three pinching methods (single, one and a-half and double pinch) by Dilta *et al*. (2006) during 2003-04 in Hamirpur, Himachal Pradesh, India and found that the maximum values for plant height (66.2 cm), stem length (54.1 cm) and flower yield m^{-2} (121.0) were recorded for crops planted in December. Flower bud formation and flowering were earliest (136.4 days and 156.2 days, respectively) in

March planting, whereas the December crop took maximum days for bud formation (161.1) and flowering (182.9).

Sharma *et al*. (2006) carried out a field experiments to study the effect of different levels of nitrogen, phosphorus and pinching (20 and 40 DAT) in African marigold (*Tagetes erecta*) cv. Pusa Narangi Gainda, during the rabi seasons of 2003-04 and 2004-05 and found that the optimum levels of nitrogen, phosphorus and pinching were assessed to be 200 kg N/ha, 100 kg P_2O_5/ha and pinching at 40 DAT for maximum growth and flower production under Jabalpur (Madhya Pradesh) conditions.

Effects of pinching time (at 7, 14, and 21 days after transplanting) and node position (4th-5th or 7th-8th node) on the growth and flowering of *G. paniculata* were studied by Cheong *et al*. (2006) during the autumn to early winter season in a subalpine area in Korea and reported that the root activity and chlorophyll content increased as pinching was delayed. The increase in plant height and leaf width was faster when pinching was conducted on the 7th-8th node. The periods of flower budding and blooming were advanced, but the flower stalk length and number of nodes was reduced by pinching on the 7th-8th node. As the time of pinching was delayed, the number of lateral shoots with flower buds and the incidence of flower malformation were reduced, whereas rosette rate was increased.

Rakesh *et al*. (2005) carried out a field experiment in Hisar, Haryana, India, during 1999 and 2000 to study the effects of GA_3 (0, 50, 100, 150 and 200 ppm) and pinching (no pinching and pinching after 35 and 45 days of transplanting) on flowering and yield of Chrysanthemum cultivars Flirt and Gauri and reported that the number of flowers per plant increased with the increase in GA_3 concentration from 50 to 200 ppm and the maximum yield was recorded at 200 ppm GA_3 for both cultivars. Pinching of plants at 35 or 45 days after transplanting caused significant increase in yield of flowers per plant compared to the control. Flirt recorded a significant increase in yield of flowers per plant compared to Gauri with different treatment combinations of GA_3 and pinching. The highest yield was recorded in Flirt with 200 ppm GA_3.

Sharma *et al*. (2005) conducted an experiment in Madhya Pradesh, India during 1999-2000 to evaluate the effect of triacontanol and pinching on the growth and yield of *Tagetes erecta*. The treatments were: control; pinching only; pinching + triacontanol spray (1.25 ppm) at 15, 30 or 45 days after transplanting (DAT); pinching + triacontanol at 15 and 30, 15 and 45, and 30 and 45 DAT; and pinching + spraying with triacontanol at 15, 30 and 45 DAT. They found that pinching followed by triacontanol spray at 15, 30 and 40 DAT increased the size and yield of flowers (8.9 cm and 36.5 q/ha), compared to the control (7.7 cm and 24.1 q/ha, respectively).

Effects of pinching (single pinching, P_1; pinch in half, P_2; and double pinching, P_3) and its combination with N treatments on the growth and flower production of carnation cv. Tasman was evaluated by Ranjit *et al*. (2005) and found that the tallest plants (69.1 cm) were obtained under $P_1 + N_2$, followed by 61.7 cm under $P_1 + N_1$. $P_3 + N_2$ showed the shortest plants (52.6 cm). $P_3 + N_2$ produced the maximum branch number (9.5), maximum plant spread (31.2 cm). $P_1 + N_2$ showed the earliest flowering (170.9 days). $P_3 + N_1$ took the longest time to flower (196.9 days). Flowering was delayed with increasing pinching intensity. N at 200 resulted in early flowering, while 500 ppm resulted in delayed flowering. Flower size was highest among pinching treatments under P_1 (5.7 cm), and lowest under P_3 (5.2 cm). The maximum flower size of 5.8 cm was obtained under P_1 + N_2 or N_1. Pinching and N treatments did not affect vase life.

A study was conducted by Rakesh *et al*. (2004) in Haryana, India, during 1999 and 2000 to determine the effects of gibberellic acid (GA_3) and pinching on the yield and quality of flowers of chrysanthemum [*Dendranthema morifolium*] cultivars Flirt and Gauri. Treatments consisted of five GA_3 rates and three stages of pinching (no pinching, pinching at 35 days after transplanting, and pinching at 45 days after transplanting). They revealed that flower size and flower stalk length were highest in non-pinched plants and sprayed with 200 ppm GA_3, whereas the yield of flowers per plant were highest in plants pinched at 35 days after transplanting and sprayed with 200 ppm GA_3 in both cultivars.

An investigation was conducted in naturally ventilated polyhouse environments in Maharashtra, India, during December 2001 to November 2002 to determine the effect of pinching methods on the growth and flowering of carnation cv. Gaudina by Chavan *et al*. (2004). Unpinched (control) plants significantly recorded the maximum plant height at every growth stage over the rest of the treatments. All pinching treatments were negatively correlated with plant height, which was significantly reduced by double pinch. Double pinched plants required more number of days (185.6) for first flowering, whereas unpinched required the least number of days (61.3). Single and half pinched plants had the longest flowering period (144.3 days) vs. the control (77.0 days). Pinching improved flower production. Linear increase in yield was recorded as the pinching severity increased. Double pinched plants were superior and recorded more yield per plant. Unpinched plants recorded longest stalks. Unpinched plants recorded the thickest stalk. Flowers from unpinched plants recorded the longest vase life (8.2 days), which was significantly reduced by double pinching (6.1 days). Application of single and half pinch method was the most effective treatment, as it staggered flower production and yielded a moderate number of flowers with intermediate quality.

An open field experiment was conducted in Nadia, West Bengal, India, by Pal and Biswas (2004) to investigate the effect of pinching and fertilizer application on the growth and flowering of carnation cultivars Desio (standard) and Supermix (spray). The greatest plant height (49.9 cm) was recorded under single pinching. Double pinching delayed flower production significantly over other methods. The longest flower stem (39.3 cm) was noted in single pinched plant. The largest flower size was recorded with the pinch and a half treatment, closely followed by the other pinching treatments. The longest duration of flowering (48.9 days) was recorded with the pinch and a half method and was at par with the double pinch method (48.5 days).

An experiment was conducted by Ramesh and Kartar (2003) to find out the effects of planting date, photoperiod, gibberellic acid, and pinching (removal of 2.0-2.5 cm of the tip of growing shoots at 4 weeks or at 4 and 8 weeks after planting) on the growth and flowering of carnation cv. Red Corso. They observed that internode length, which is an index of plant height and flower stalk length, did not vary with the planting date. The longest internodes were obtained under pinching once (7.4 cm). Pinching increased the number of leaf pairs, and higher number of leaf pairs was obtained with pinching twice (19.3). The treatments that reduced the number of leaf pairs also reduced the number of days to full bloom and final harvesting of cut flowers.

Beniwal *et al*. (2003) carried out an experiment in Haryana, India, during 1999-2000 to determine the optimum plant spacing and pinching time for higher flower production in chrysanthemum [*Dendranthema morifolium*]. Treatments comprised: 3 row spacings; and no pinching, pinching at 25, 35 and 45 days after transplanting (DAT). Plant height, number of branches per plant and flower yield were highest (39.79 and 47.75 cm, 9.93 and 10.21 branches, and 3.03 and 3.68 kg/plot during 1999 and 2000, respectively) at 25 DAT for both years.

Rakesh *et al*. (2003) conducted an experiment to evaluate the effects of gibberellic acid and pinching (at 35 or 45 days after transplanting or DAT) on the growth and yield of chrysanthemum (*Dendranthema grandiflora* [*Chrysanthemum morifolium*, syn. D. *morifolium*]) cultivars Flirt and Gauri in Hisar, Haryana, India, during 1999 and 2000. From the findings they reported that Pinching of plants generally reduced plant height compared to the control. Plant spread increased with pinching at 35 DAS. Pinching at 35 and 45 DAS significantly increased the number of branches over the control. Interaction effects showed that the greatest plant spread (37.5 cm) and number of branches per plant (16.1) was recorded for Gauri treated with 200 ppm gibberellic acid. Flower yield per plant was highest (117.7 g) in Flirt treated with 200 ppm gibberellic acid.

The effects of chlormequat and maleic hydrazide, as well as of pinching (pinching 20 or 30 days after planting) on the growth and yield of African marigold were determined in a field experiment conducted by Khandelwal *et al*. (2003) in Rajasthan, India during the rainy season of 2001-02. The values for the parameters measured were higher with early than late pinching except for internode length. The number of days to first flowering and duration of flowering were lower, whereas flower weight, intact flower longevity, number of flowers and yield were higher with early than late pinching.

The effects of foliar spraying of gibberellic acid and pinching once after 4 weeks of planting or twice after 4 and 8 weeks of planting on the growth of carnation cv. Red Corso were determined in pot experiments conducted by Ramesh and Kartar (2003) in Hisar, Haryana, India during 1994-95. Pinching twice resulted in higher number of side shoots, leaves and flowers; dry weight of plant; number of days before the first flowering and number of peak flowering days compared to pinching twice. Plant height, leaf length, weight of flower and flower freshness were higher in unpinched than pinched shoot tips. The interaction effects between gibberellic acid application and pinching were significant for all the parameters examined.

The effects of N and K, as well as of pinching (0, 10, 20 and 30 days after potting) on the growth and flowering of chrysanthemum (*Dendranthema morifolium*) cv. Jayanthi were determined by Singh and Baboo (2003). They found that the values for all the parameters measured increased with the delay in pinching except for plant height which was highest with pinching after ten days of potting.

The effects of N rates and pinching (at 30, 40 or 50 days after transplanting or DAT) on the performance of *T. erecta* cv. African Giant Double Orange were studied in Hisar, Haryana, India, during 1997-98 by Sehrawat *et al*. (2003) and found that pinching significantly reduced plant height, especially when conducted at 30 DATs. The highest number of flowers per plant (30.2) and flower yield (322.6 g per plant) were obtained with pinching at 30 DAT (30.2).

Ryu *et al*. (2002) conducted an experiment to find out the effects of uniconazole and pinching on growth and flowering of *H. asiatica* after dormancy breaking by gibberellin (GA_3) and reported that pinched plants had more number of shoots, leaves and flowers. One-time pinching combined with 1 mg/litre uniconazole produced the shortest plants compared with other pinching treatments in pot culture of *H. asiatica*.

In order to obtain basic data for production of flowering pot plants with good quality, the effects of pinching frequencies and growth regulators on growth and flowering of *S. rotundifolium* were investigated by Jeomg (2000) and reported that numbers of lateral shoots and flowers increased with an increase in pinching frequency.

Effects of pinching and foliar spray of daminozide on growth and flowering of *C. zawadskii* subsp. *naktongense* were investigated by Yoo *et al*. (1999) and found that double pinching was more effective at reducing plant height than no or single pinching. Pinching resulted in a decreased number of shoots and flowers, and delayed flowering by 9-27 days. Double foliar spray at 25 mg daminozide/pot or single foliar spray at 50 mg daminozide/pot after single pinching were the most effective treatments at reducing plant height.

2.2 Foliar application of growth chemicals on flowering plant

Pyrethrins and flower yield of pyrethrum (*Chrysanthemum cinerariaefolium* Viz.) plants were determined by Haque *et al*. (2007) after application of ethrel, chlormequat chloride and paclobutrazol. Ethrel at 50, 100, 250 and 500 mg /l produced a significant positive effect on pyrethrins level, decreased plant height, while 50 and 100 mg/l significantly increased fresh and dry flower yield. Chlormequat chloride at 1000 and 2000 mg /l and paclobutrazol (80 and 160 mg

/l) increased pyrethrins level, single flower weight and decreased plant height and flower yield.

A field experiment was conducted by Moond *et al*. (2006) to investigate the effects of foliar sprays of gibberellic acid (GA_3; at 50, 100, 150, 200 and 250 ppm), CCC (chlormequat; at 2000, 4000, 6000, 8000 and 10 000 ppm) and maleic hydrazide (MH; at 250, 500, 700, 1000 and 1250 ppm) on the yield and quality of chrysanthemum (Chrysanthemum indicum cv. Local), well adapted under agroclimatic conditions of Udaipur, Rajasthan, India. Diameter and fresh weight of flowers increased significantly over the control with all the levels of GA_3 and flowers with the largest diameter (6.5 cm) and greatest weight (2.3 g) were recorded with GA_3 at 150 ppm. CCC and MH had no significant effect on flower diameter, although fresh weight of flowers increased significantly over the control (2.30 and 2.28 g at 2000 ppm CCC and 250 ppm MH, respectively). All the treatments, except for GA_3 at 250 ppm, recorded significantly higher number of flowers per plant over the control. The highest number of flowers (371) was recorded by spraying 1250 ppm MH.

Studies were undertaken during 2002-03 by Gautam *et al*. (2006), in Udaipur, Rajasthan, India, to investigate the effect of plant growth regulators, i.e. GA_3 (50, 100, 150 and 200 ppm), NAA (50, 100, 150 and 200 ppm), Ethrel [ethephon] (>50, 1000, 1250 and 1500 ppm) and B-nine [daminozide] (1000, 1500, 2000 and 2500 ppm), on the growth, flowering and yield chrysanthemum cv. Nilima. The results revealed that GA_3 at all concentrations and NAA at 100 ppm increased plant height, internal length and basal diameter, while ethrel and B-nine at all concentrations retarded plant height, number of nodes and internodal length over control. Extremely early or late flowering were recorded with GA_3 at 150 ppm and B-nine at 2500 ppm, respectively. Similarly, GA_3 at 150 ppm caused the longest flowering phase, while ethrel at 1500 ppm resulted in the shortest flowering phase. Number of flowers per plant was more than the control in all the treatments, except ethrel at 1250 and 1500 ppm. Among all the treatments, GA_3 at 200 ppm registered the maximum flower size and yield of chrysanthemum.

Zheng *et al*. (2005) conducted an experiments to find out the effects of calcium (Ca) and magnesium (Mg) treatments on growth, nutrient contents, ethylene evolution, and gibberellin (GA) content of *Dendranthema grandiflora* [*D. morifolium*] were investigated. Treatments were as follows (per pot): 0.0 g Ca or Mg (control), 0.2 g Ca, 0.5 g Ca, 0.2 g Ca+0.2 g Mg, 0.5 g Ca+0.2 g Mg, and 0.2 g Mg. Plant height increased significantly in 0.5 g Ca and 0.5 g Ca+0.2 g Mg treatments but not in other treatments. Shoot dry weight increased in all the treatments except in 0.2 g Mg treatment compared with the control. GA_3 and GA_3 like substance contents did not change in plants treated with 0.2 g Ca, 0.5 g Ca or 0.2 g Mg but decreased in Ca+Mg-treated plants compared with the control. Thus, Ca and Mg treatments affect not only the growth of chrysanthemum plants and nutrient contents but also the GA activities and ethylene evolution.

An experiment was conducted by Gruszczyk and Berbec (2004) on sandy loam soil in 2000-02 to compare the effect of the foliar application of Atonik (0.2%), Ekolist (0.2%), Bioalgeen S-90 (0.3%) and water extract from dry great nettle [Urtica] (diluted in water 1:10) on feverfew (*C. parthenium* [*Tanacetum parthenium*]). Preparations were sprayed on plants 3 times: 20 May, 2 and 19 June. All preparations had a positive effect on the growth and development of plants, resulting in a significant increase of the yield and active component content of partenolid. Out of the preparations used, the most effective were Atonik and extract from great nettle (yield increase by 63 and 54%, respectively).

Influence of a single foliar application of growth regulators on the height and number of inflorescence shoots of the chrysanthemum cultivar 'Revert' was investigated by Karlovic *et al*. (2004) during two growing seasons (2000, 2001) and two growth regulators were used, daminozide (Alar 85) and chlormequat (Cycocel). Daminozide was applied in concentrations of 1000, 2000 and 3000 mg /L and a control (without treatment) while chlormequat was used in concentrations of 2000, 3000, 4000 mg / L and a control (without treatment). The concentrations used differed significantly in their effects on plant height in both years whereas their effects on the number of inflorescence shoot were not significantly different. Daminozide concentration of 3000 mg/L was the most efficient concentration in the first year and that of 2000 mg l-1 in the second year. However, as no statistically significant differences between these two concentrations were recorded in either year, the use of the lower daminozide concentration in height regulation of 'Revert' chrysanthemum is recommended for environmental reasons. In the second trial year daminozide concentrations were more efficient in regulating the upward growth than chlormequat concentrations while this was not the case in the first year.

Shima *et al*. (2004) conducted an experiment with nitrogen fertilizer (267 mg/shoot) that was basally applied to each plot of spray chrysanthemums at 0, 25, 50, 75 and 100% respectively. The residual nutrients, divided into 10 equal dosages, were applied weekly. Nitrogen fertilizer was also applied at the recommended rate (500 mg/shoot). The initial growth of chrysanthemums in the 25 and 50%-treated plots was better than in the other plots. Necrosis due to excessive fertilization was observed on the leaves in the 75 and 100%-treated plots. Regardless of the ratio of basal fertilizer to total application, cut flower quality was still good and marketable. Cut flower quality from the control plot was lower than those in the other plots due to excessive plant growth. Maintenance of the initial nitrate levels ranging from 50 to 300 ppm at planting using a soil solution is recommended.

An experiment was carried out by Kim *et al*. (2003) to promote occurrence of suckers and elongation of lateral shoot, and to improve cut flower quality with GA_3 (gibberellic acid) treatment in secondary flowering of *D. grandiflorum* 'Baegkwang' and sated that the occurrence of sucker and lateral shoot elongation were increased by the application of BA, NAA, ethephon, and kinetin. Especially, 200 mg/L BA induced the number of suckers, middle and upper shoots, while 200 mg/L kinetin increased the number of suckers but decreased those of middle and upper shoots.

Gruszczyk and Berbec (2003) conducted a field experiment in Tamil Nadu, India, during 1999-2000 to determine the effects of GA_3, salicylic acid and triacontanol on the growth and development of chrysanthemum [*Chrysanthemum morifolium*, syn. *Dendranthema morifolium*] cultivars Baggi, Indira, Red Gold and Shymal. The treatments comprised: 100 and 150 ppm GA_3; 50 and 100 ppm salicylic acid; 1, 2 and 3 ppm triacontanol 0.1, 0.2 and 0.3 ppm brassinolide; and water (control). The treatments were applied thrice from 15 to 30 days after transplanting. Shymal treated with 150 ppm GA_3 gave the highest plant height (67.88 cm) while Bagg treated with 3 ppm triacontanol gave the highest number of suckers per plant. Red Gold treated with 150 ppm GA_3 and 100 ppm salicylic acid gave the highest number of branches per plant (15.75) and flower yield per plant (370.65), respectively.

A field experiment was ccrried out by Mohariya *et al*. (2003) in Nagpur, Maharashtra, India, during 2000-01 on Chrysanthemum morifolium cultivars Sonali Tara, Birbal Sahani, Sharad Shrungar, and Julia to determine the effect of plant growth regulators on growth, flowering, and yield characteristics. The treatments comprised of gibberellic acid (100 and 150 ppm) and TIBA (100 and 200 ppm). Gibberellic acid increased plant height, where Birbal Sahani had the highest plant height with 150 ppm gibberellic acid. TIBA at 100 ppm recorded the highest number of branches per plant with Sharad Shrungar. Flowering was hastened with 150 ppm gibberellic acid but was delayed with TIBA. The earliest flowering date was observed with Sharad Shrungar. Gibberellic acid increased flower diameter and vase life, and was highest with Sonali Tara. The number of flowers increased with gibberellic acid treatments followed by TIBA treatments.

Mohariya *et al*. (2003) conducted an experiment to find out the effects of gibberellic acid (GA_3) at 100 and 150 ppm, and TIBA at 100 and 200 ppm on the growth and flowering of chrysanthemum [*Dendranthema morifolium*] cultivars Sonali Tara, Birbal Sahani, Sharad Shrungar and Julia in Maharashtra, India. The growth regulators were sprayed to plants at 30 and 60 days after the transplanting of rooted cuttings. Plant height was increased with GA_3 but was reduced by TIBA application. Birbal Sahani treated with 150 ppm GA_3 produced the tallest plants (52.80 cm). The number of branches, flower yield, and flower weight significantly increased with the application of both growth regulators. Sharad Shrungar sprayed with 100 ppm TIBA recorded the highest number of branches per plant (21.1). GA_3 induced early flowering, whereas TIBA delayed flowering. Sharad Shrungar sprayed with 150 ppm GA_3 exhibited the earliest flowering (85.6 days). Flower size increased with the increase in the concentration of GA_3 and TIBA. Sonali Tara with 150 ppm GA_3 produced the largest flowers (4.8 cm). Julia sprayed with 150 ppm GA_3 recorded the highest number of flowers per plant (90.2), whereas Birbal Sahani treated with GA_3 at similar concentration registered the maximum flower weight (80.8 g).

The effect of ethephon applications on growth and morphology in summer to autumn flowering chrysanthemum (*Dendranthema grandiflorum*) was studied by Sugiura and Fujita (2003) for forced cut flower production under open culture. Flower bud differentiation of 'Madobe' and 'Summer-yellow' was strongly inhibited by 200-400 mg/l ethephon applications when sprayed at 0-1000 mg/l ethephon concentrations. Leaf increasing terms of some cultivars were more elongated by 800-1000 mg/l ethephon applications than by 200 mg/l and others were the same elongation when sprayed with 0-1000 mg/l ethephon concentrations. Cultivars with longer internodes showed higher stem elongation using 200 mg/l ethephon sprays than those with shorter internodes. Leaf number and stem length did not increase, and malformations occurred when sprayed with 200 and 1000 mg/l ethephon after bud differentiation in flower buds, flowers and peduncle.

Khobragade *et al*. (2002) used rooted cuttings of six large-flowered chrysanthemum (*Dendranthema* sp.) cultivars (Raja, Red Spoon, White Ball, Golden Splender, Beauty, and Violet Spoon) were planted in polythene bags during the spring of 1998 and were sprayed once with growth retardant B-9 (daminozide) at five levels (0, 2000, 3000, 4000, and 5000 ppm) one month after planting. Results showed that increasing concentration of B-9 upto 5000 ppm reduced the vegetative growth of plant, as evident in reduced plant height, number of leaves, number of internodes, length of internode, and increased stem thickness, causing the development of dwarf, stiff, sturdy, and woody plants bearing large (16.1 to 17.0 cm), heavy (25.7 to 31.5 g) flowers of good ornamental value resting firmly on natural support.

Kim *et al*. (2001) studied the effects of shading and GA_3 and ethephon application on the growth and quality of cut flowers of Baegkwang chrysanthemums (*Dendranthema grandiflorum*) and found that generally, growth and flowering were better in 30% shading treatment than in the non-shading control. Occurrence of physiological injury was remarkably reduced in 30% shading treatment compared to the non-shading control. This data indicates that a 30% shading treatment increases the yield of cut flowers. Plant height and length of flower stalk increased as the application level of GA_3 increased. The number of days to flowering was shortened by GA_3 treatment. The number and width of leaves increased with higher concentrations of ethephon, but were reduced by the shading treatment. Marketable yield of cut flowers reduced as the level of ethephon increased.

The dwarfing effect of daminozide and chlormequat on the spray chrysanthemum was investigated by Kwon *et al*. (2001) and found that the long neck of cut-chrysanthemum break easily. The peduncle length of cultivars Biarittz and Vyking were retarded by the foliar spray treatment of 1500 mg daminozide/litre. Daminozide application did not affect plant growth of Biarittz and Vyking. However, the number of days to flowering in Biarittz was delayed by 3 days by daminozide application. The length of cut flowers of Vyking was decreased by the application of daminozide. Chlormequat application did not affect dwarfing of peduncle length in chrysanthemum.

The effect of B-9 (daminozide) on the dwarfing and decorative behaviour of chrysanthemum (*Chrysanthemum indicum*) cultivars White Ball, Flirtation, Kamal, Beauty, Raja and Achievement was investigated in a field experiment conducted by Mahalle *et al*. (2001) in Nagpur, Maharashtra, India, during 1997-98. Rooted cuttings of chrysanthemum were planted in August 1997 in polyethylene bags of size 22.5 × 15 cm filled with 1.2 kg of pot mixture consisting of decomposed FYM, leaf mould and soil at 2:2:1 ratio, and sprayed with B-9 at 0, 1000, 2000, 3000 and 4000 ppm concentrations one month after planting. All the concentrations of B-9 were effective in reducing height, number of leaves and internodes, length of internode, leaf area per plant and fresh and dry weight of plant, excluding flower, and increasing thickness of stem and leaves, and chlorophyll content of leaves. B-9 at 4000 ppm was found most effective in reducing height and increasing thickness of stem. However, B-9 at 4000 ppm recorded the least number of leaves and lowest dry weight of plant, excluding flowers, in Raja and least number of internodes and leaf area per plant in flirtation.

The effect of gibberellic acid (GA; sprayed at 50, 100 and 200 mg/litre) on growth and flowering of *C. morifolium* cv. Jayanti was investigated by Gupta and Datta (2001) and reported that GA was effective at all concentrations in increasing the plant height and cut flower yield. The optimum increase in these parameters was observed at 100 mg GA/l.

An experiment was conducted by Kim *et al*. (2000) about the cultivation of chrysanthemums (*Dendranthema grandiflorum*) cv. Baegkwang, in its second flowering, for off-season cut flower production and found that The replanted crops flowered 5-6 days earlier than the second flowering crops. Plant height and length of flowering stalk increased with increasing concentrations of gibberellic acid (GA_3 0, 100, 200 or 400 mg/l). However, the quality of cut flowers and marketable yield significantly increased with the GA_3 treatments compared to the control.

Fujii and Sasaki (2000) reported that in 6 non-branching cultivars of chrysanthemum (*D. grandiflora* [*D. morifolium*]), branching in all cultivars was significantly increased by application of 300 ppm benzyladenine, in 4 cultivars it was also increased, but to a lesser extent, by application of 50 ppm gibberellic acid, and in one cultivar branching was increased by application of 13.3 ppm IAA. In a further trial with 5 cultivars, spraying with benzyladenine at 150 ppm gave more branching in 3 cultivars than 50 or 300 ppm while 300 ppm resulted in more branches in one cultivar and 50 ppm benzyladenine resulted in more branches in the other cultivar.

Jeong and Kim (2000) carried out an experiment to investigate the effects of uniconazole on the growth and flowering of potted chrysanthemums for high quality pot plant production. Uniconazole was drenched at 0.05, 0.01 or 0.15 mg a.i./pot at 14 days after planting (DAT) of rooted cuttings. Simultaneously the short-day treatment (SDT) and pinching were adapted. The same amount of uniconazole (0.05 mg a.i./pot) was split drenched once, twice or three times at 1 week intervals. Uniconazole markedly reduced plant height, branch length and stem diameter. Plant height was reduced linearly with increasing uniconazole concentration (by 41.6, 52.5 and 58.5%, respectively). In 0.05 mg a.i./pot, the number of branches greatly increased and plant height of 22.6 cm was adequate for pot plant. Number of visible buds was highest in the 0.05 mg a.i./pot uniconazole treatment. Flower diameter was decreased by uniconazole treatment, resulting in compact form.

The effect of plant growth regulators (gibberellic acid and NAA at 10, 50 and 100 ppm, and CCC at 500, 1000 and 1500 ppm) on the growth and flowering of Chrysanthemum sp. cv. Local was investigated by Sharad *et al*. (2000) and reported that GA increased plant height, and the maximum height was obtained at 100 ppm GA. CCC at 1500 ppm reduced plant height compared to the control. NAA also increased plant height compared to the control. GA reduced the time required for flowering, while NAA and CCC delayed flowering. The highest delay in flowering was at 1500 ppm CCC and flowering was earliest at 100 ppm GA.

An attempt was made by Farooqi *et al*. (1999) to introduce pyrethrum (*C. cinerariaefolium*) from the hills of Kashmir and Kodaikanal to Lucknow conditions of north Indian plains. The percentage of flowering plants increased significantly with application of kinetin (100 ppm) or GA_3 (100 ppm) + kinetin (100 ppm). The number of flowers/plant was significantly increased over the control in GA_3 treated plants. Application of kinetin increased pyrethrin content by 39% and pyrethrin yield by 27% over control. Seeds showed better germination when treated with 100 ppm GA_3.

Meher *et al*. (1999) carried out a field experiment at Pune in 1992-93, chrysanthemums were planted in the first week of May, June or July and sprayed twice (30 and 50 days after planting) with 10, 20 or 30 ppm IAA, 50, 100 or 150 ppm GA or 150, 300 or 450 ppm maleic hydrazide and reported that of the growth regulator treatments, 50 ppm GA and 20 ppm IAA gave the highest yields. The number of days to 50% flowering was least from planting in July and following application of 20 ppm IAA. Maleic hydrazide tended to delay flowering compared with the other growth regulators. Flower diameter ranged from 4.43 cm with 450 ppm maleic hydrazide to 7.14 cm with 150 ppm GA.

CHAPTER III

MATERIALS AND METHODS

Materials and methods that were used for conducting the experiment are presented under the following headings:

3.1 Experimental site

The experiment was conducted at Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from October 2008 to March 2009. Location of the site is 23º74′ N latitude and 90º35′ E longitude with an elevation of 8.2 meter from sea level (Anonymous, 1981).

3.2 Climatic condition

Climate of the experimental site is subtropical, characterized by heavy rainfall during the months from April to September (Kharif season) and scanty rainfall during the rest of the year (Rabi season). Maximum and minimum temperature, humidity and rainfall during the study period were collected from the Bangladesh Meteorological Department (climate division), Agargaon, Dhaka and have been presented in Appendix I.

3.3 Planting materials

Suckers of chrysanthemum were used for the experiment and these were collected from Agritech Nursery, Khamarbari, Farmgate, Dhaka.

3.4 Treatment of the experiment

. The experiment considered as two factors.

Factor A: Pinching (2 levels):

i. P_0: Without pinching

ii. P_1: With pinching (Removal of 2.0-2.5 cm of the tip of growing shoot at 3 weeks after transplanting)

Factor B: Foliar application of growth chemicals (5 levels):

i. F_0: Control

ii. F_1: Wuxol (2.5 ml/l)

iii. F_2: Vegimax (2.5 ml/ l)

iv. F_3: Agro grow (2.5 ml/ l)

v. F_4: Surgrow (2.5 ml/ l)

There were the 10 (2 × 5) treatment combinations such as P_0F_0, P_0F_1, P_0F_2, P_0F_3, P_0F_4, P_1F_0, P_1F_1, P_1F_2, P_1F_3 and P_1F_4.

3.5 Ingredients of the foliar application components

i. **Wuxol (F_1)** : N, P, K and some micronutrients, Bayer Crop Science Limited, Bangladesh.

ii. **Vegimax (F_2)** : Ingredients- N_2-5.5, P_2O_5-6%, K_2O-5%, S-0.35%, Zn-0.03%, B-0.03%, Cu-0.02%, Mn-0.04%, Fe-0.13%, Mo-0.003%, Cl-0.4%, Vitamin and amino acids, Genetica,Bangladesh.

iii. **Agrogrow (F_3)**: IAA (Indole-3-Acetic Acid), Mamun Agro-Products Limited, Bangladesh.

iv. **Surgrow (F_4)** : Growth hormone (Including GA_3 and others), Kustia seed Store, Bangladesh.

3.6 Pot preparation

Soil and cowdung (1.5 kg/pot) were mixed and pots were filled 7 days before transplanting. Weeds and stubbles were completely removed from the soil. No chemical fertilizers were used.

3.7 Design and layout of the experiment

Two factor experiment was laid out in Complete Randomized Design (CRD) with three replications.

3.8 Planting of suckers

Suckers were planted at 7 cm depth in pot on 15 October, 2008 with sufficient care for minimum injury of suckers. 30 pots were used in this experiment and single plant in each pot.

3.9 Intercultural operation

3.9.1 Tagging of plants

Plants were marked with tags as the treatments to collect data.

3.9.2 Weeding

Weeding was done in all the pots as and when required to keep the plant free from weeds by hand picking.

3.9.3 Irrigation

Frequency of watering depended upon the moisture status of the soil. However, water logging was avoided, as it is harmful to plants.

3.9.4 Disease and pest management

During the early growing stage powdery mildew and leaf spot were controlled by spraying Dithane M-45. Fungicide was sprayed two times at 15 days interval. Crop was also attacked by aphids during the growing stage. Aphid was controlled by spraying Malathion @ 1.5 ml/l. Insecticides were sprayed two times at seven days interval.

3.10 Data collection

Data were collected in respect of the following parameters from each pot with in the mentioned period.

3.10.1 Plant height

Height of plant refers to the length of the plant from ground level up to the tip of the longest leaf and it measured in cm at every 10 days interval after 20 days of transplanting (DAT) and continued up to 90 DAT.

3.10.2 Number of leaves per plant

Number of leaves per plant was recorded by counting all the leaves from each plant of each pot. It was measured in number at every 10 days interval after 20 DAT and continued up to 90 DAT.

3.10.3 Number of branches per plant

Number of branches produced in each plant was recorded by counting all the branches of each plant. It was measured in number at every 10 days interval after 20 DAT and continued up to 90 DAT.

3.10.4 Number of flower buds per plant

Number of flower buds produced in each plant was recorded by counting all the flowering buds of each plant. It was measured in number at every 10 days interval after 40 DAT and continued up to 110 DAT.

3.10.5 Number of flowers per plant

Number of flowers produced in each plant was recorded by counting all the flower of each plant. It was measured in number at every 10 days interval after 60 DAT and continued up to 130 DAT.

3.10.6 Days to bud initiation

Days to bud initiation were measured by counting the number of days from transplanting to bud initiation when buds were visible.

3.10.7 Days to flower initiation

Days to flower initiation were measured by counting the number of days from bud initiation to flower initiation when flower started to open.

3.10.8 Flower durability in plant

Flower durability in plant was measured by counting the duration of time in days that flower remains good condition in plant.

3.10.9 Petal color measurement

Petal color at three different locations of the outer epidermis (ø 10 mm) was measured using a handy-type tristimulus colorimeter, NR-3000 (NIPPON Denshoku), followed by L* (lightness), a*, and b* (two Cartesian co-ordinates), based on the CIElab scale with the standard CIE observer (10^0 visual field) and the CIE standard illuminant D_{65} (CIE, 1986; McGuire, 1992), (Plate 1 & 2). Beams whose effective axes were at the angle of 45 ± 2^0 from the normal of the specimen surface in illuminated petal. Metric chroma, C* and hue angle, h_{ab} (CIElab notation), were calculated according to the following equations: $C^* = (a^{*2} + b^{*2})^{0.5}$ and $h_{ab} = tang^{-1} (b^*/a^*)$ (Gonnet, 1998).

Plate 1. Colorimeter (Nippon Denshoku, NR- 3000)

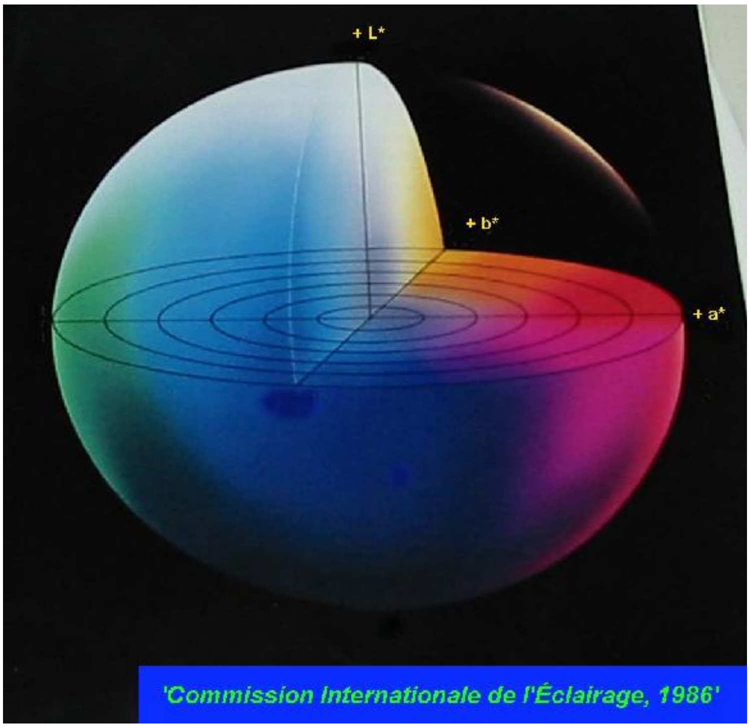

Plate 2. CIELab color scale

3.11 Statistical analysis

Collected data for various characters were statistically analyzed using MSTAT program. Mean for all the treatments was calculated and the analysis of variance for each of the characters was performed by F (variance ratio) test. Difference between treatments was evaluated by Duncan's Multiple Range Test (DMRT) test at 5% level of significance (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was carried out to find out the influence of pinching and foliar application of growth chemicals on growth and yield of chrysanthemum. Data on different growth parameter, flower production and color of chrysanthemum was recorded and the analysis of variance (ANOVA) of the data on different parameter is presented in Appendix II-VIII. Some of the data have been expressed in table (s) and others in figure (s) for ease of discussion, comprehension and understanding. Results of the study are presented under the following heads.

4.1 Results

4.1.1 Plant height

Significant variation was recorded for plant height due to the terminal bud pinching in chrysanthemum at 20, 30, 40, 50, 60, 70, 80 and 90 DAT (Appendix II). Gradually increasing trend of plant height was observed with days after transplanting (Figure 1). Tallest plant (37.7 cm) was recorded from P_0 and the shortest plant (33.4 cm) was found from P_1 with 90 DAT. Pinching (P_1) create a stress condition and cannot accomplish vegetative growth and the ultimate results was the shortest plant compared to without pinching (P_0) because without pinching terminal bud helps to attained optimum vegetative growth without disruption of normal plant growth of chrysanthemum. Yoo *et al*. (1999) found that double pinching was more effective at reducing plant height than no or single pinching. Similar opinion was also put expressed by Dilta *et al*. (2006), Rakesh *et al*. (2005), Pal and Biswas (2004) and Khandelwal *et al*. (2003). There were some findings that disagree with the present findings. Brum *et al*. (2007) reported that plant height increased as the number of pruning than the control condition. Cheong *et al*. (2006) also reported that the increase in plant height and leaf width was faster when pinching was conducted on the 7th-8th node.

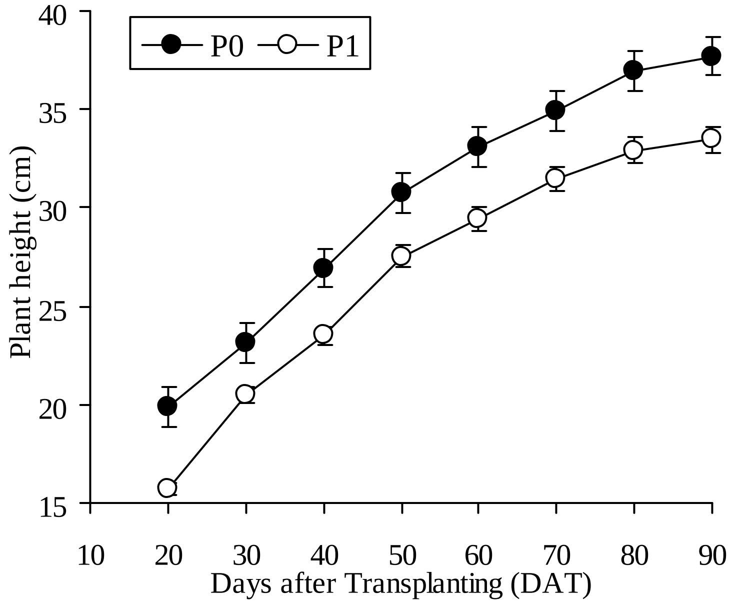

Fig. 1. Effect of pinching on plant height of chrysanthemum; P_0, Without pinching; P_1, With pinching.

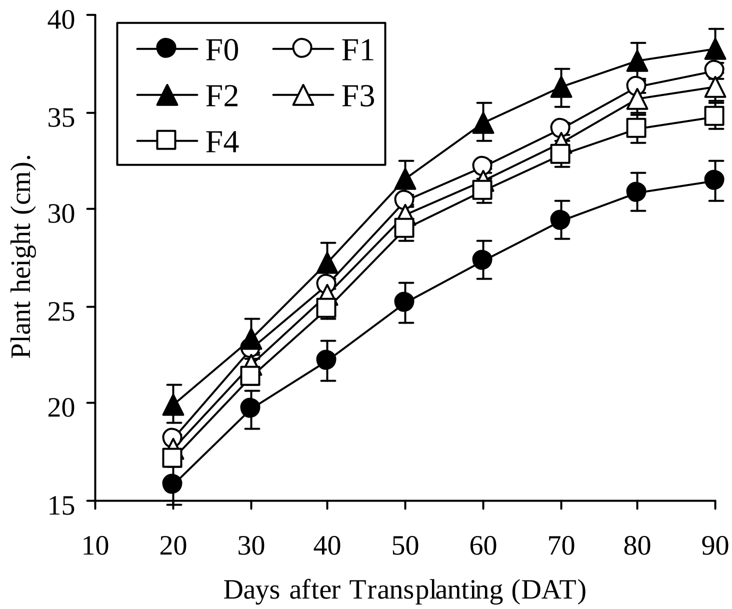

Fig. 2. Effect of foliar application of growth chemicals on plant height of chrysanthemum; F_0, Control; F_1, Wuxol; F_2, Vegimax; F_3: Agro grow and F_4: Surgrow

Chrysanthemum plant height showed significant variation with control for different foliar application at 20, 30, 40, 50, 60, 70, 80 and 90 DAT (Appendix II). Figure 2 represents a gradual increasing trend of plant height with days after transplanting for different foliar application. The tallest plant (38.2 cm) was recorded from F_2 again, the shortest plant (31.4 cm) was found from F_0 at 90 DAT. Vegimax (F_2) content N, P, K, S, Zn, B, Cu, Mn, Fe, Mo, Cl, vitamin and amino acids and Wuxol (F_1) content also N, P, K and other micronutrients in liquid and available form, so it is a balance nutrient mixture for vigorous and healthy plant growth. On the other hand, agrogrow (F_3) and surgrow (F_4) both are also growth hormone and helps to rapid vegetative growth. Gruszczyk and Berbec (2004) reported that foliar application had a positive effect on the growth and development of plants, resulting in a significant increase of the plant height. Moond *et al*. (2006) reported that foliar sprays of gibberellic acid increased plant height. Similar findings also reported earlier by Gautam *et al*. (2006), Zheng *et al*. (2005), Mohariya *et al*. (2003), Mohariya *et al*. (2003) with using different growth regulators as foliar spray.

Combined effect of terminal bud pinching and foliar application in terms of plant height of chrysanthemum showed significant variation at 20, 30, 40, 50, 60, 70, 80 and 90 DAT (Appendix II). Table 1 show a gradual increasing trend of plant height with days after transplanting for the combined effect of pinching and different foliar application. The tallest plant (43.2 cm) was recorded from P_0F_2 and the shortest plant (30.6 cm) was obtained from P_1F_0 with 90 DAT (Table 1). Combination of pinching and foliar application influenced vegetative growth as well as plant height. Without pinching (P_0) and Vegimax (F_2) leads to attaining tallest plant among the combinations.

Table 1. Combined effect of pinching and foliar application of growth chemicals on plant height of chrysanthemum[Y]

Treatments[X]	Plant height (cm) at							
	20 DAT	30 DAT	40 DAT	50 DAT	60 DAT	70 DAT	80 DAT	90 DAT
P_0F_0	15.8 c	19.8 d	22.6 d	25.7 ef	28.6 d	29.5 e	31.6 ef	32.2 cd
P_0F_1	19.8 ab	24.0 ab	27.4 b	31.5 b	33.0 b	35.5 b	38.0 b	39.2 ab
P_0F_2	22.9 a	25.5 a	29.6 a	34.0 a	37.3 a	40.0 a	42.3 a	43.2 a
P_0F_3	20.2 ab	23.3 abc	27.7 b	31.6 b	33.1 b	34.7 bc	36.2 bcd	36.8 bc
P_0F_4	20.5 a	23.3 abc	27.1 b	31.0 bc	33.4 b	34.9 bc	36.4 bc	36.9 bc
P_1F_0	15.7 c	19.6 d	21.7 d	24.6 f	26.1 e	29.4 e	30.1 f	30.6 d
P_1F_1	16.6 c	21.6 bcd	24.8 c	29.3 cd	31.3 bc	32.7 bcd	34.5 bcdef	35.0 bcd
P_1F_2	17.0 bc	21.1 cd	24.8 c	29.0 cd	31.6 bc	32.5 bcd	32.8 cdef	33.2 cd
P_1F_3	15.2 c	20.7 d	23.4 cd	27.6 de	29.6cd	32.1cde	35.0 bcde	35.8 bc
P_1F_4	13.7 c	19.3 d	22.6 d	26.9 e	28.3 d	30.7 de	31.8 def	32.6 cd
$LSD_{(0.05)}$	3.056	2.171	1.838	1.888	2.040	2.768	4.056	4.299
Significance level	0.05	0.05	0.05	0.05	0.05	0.01	0.05	0.05
CV(%)	10.09	5.83	8.28	9.80	6.83	7.89	6.82	7.09

[X]P_0: Without pinching; P_1: With pinching; F_0: Control; F_1: Wuxol (2.5 ml /L of water); F_2: Vegimax (2.5 ml/L of water); F_3: Agro grow (2.5 ml/L of water); and F_4: Surgrow (2.5 ml/L of water)

[Y]In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

4.1.2 Number of leaves per plant

Number of leaves per plant showed significant differences due to pinching in chrysanthemum at 20, 30, 50, 60, 70, 80 and 90 DAT but for 40 DAT variations was statistically significant (Appendix III). Gradually increasing trend of number of leaves per plant was observed with days after transplanting. At 40 DAT the maximum number of leaves per plant (18.6) was observed from P_0 and the minimum number of leaves per plant (17.9) was observed from P_1. At 90 DAT the maximum number of leaves per plant (30.1) was recorded for P_1, while the minimum number of leaves (26.8) was obtained from P_0 (Figure 3). Similar results were reported by Ramesh and Kartar (2003) and Ryu *et al*. (2002).

Significant variation was observed for number of leaves per plant of chrysanthemum for different foliar application at 20, 30, 40, 50, 60, 70, 80 and 90 DAT (Appendix III). The maximum number of leaves per plant (31.6) was observed from F_2 again the minimum number of leaves per plant (21.3) was recorded from F_0 (Figure 4). Sugiura and Fujita (2003) and Khobragade *et al*. (2002) also reported similar opinion.

Terminal bud pinching and foliar application showed significant differences for combined effect in terms of number of leaves per plant of chrysanthemum at 20, 30, 40, 50, 60, 70, 80 and 90 DAT (Appendix III). Maximum number of leaves per plant (21.0) was found from P_0F_2 at 40 DAT. Again 90 DAT the maximum number of leaves per plant (33.6) was recorded from P_1F_2. On the other hand, the minimum number of leaves per plant (21.0) was recorded from P_1F_0 at the same days after planting, respectively (Table 2).

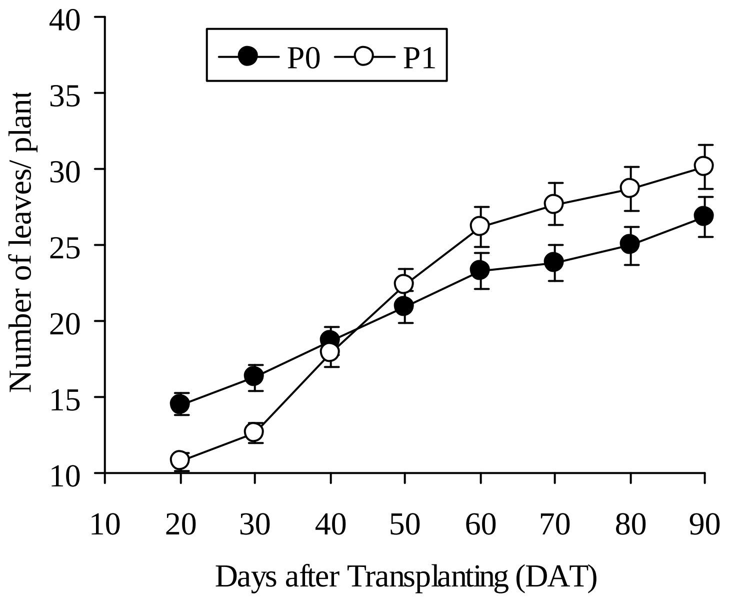

Fig. 3. Effect of pinching on number of leaves/plant of chrysanthemum; P_0, Without pinching; P_1, With pinching.

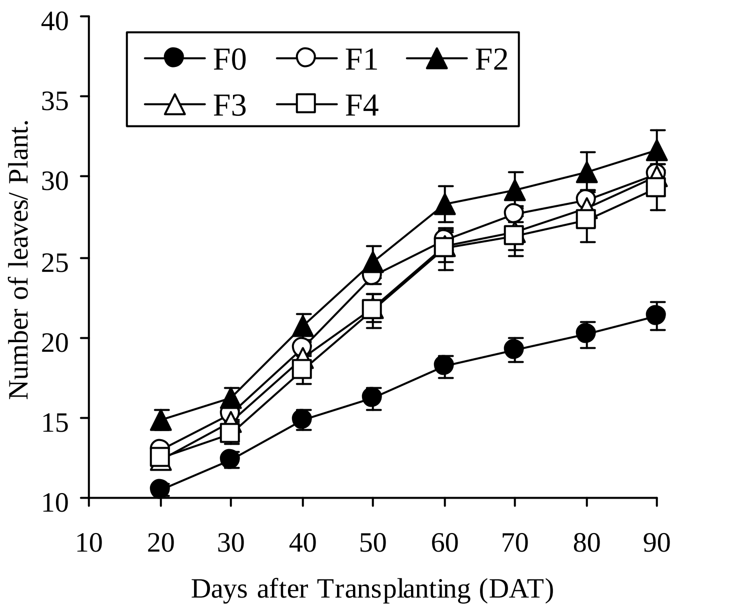

Fig. 4. Effect of foliar application of growth chemicals on number of leaves/plant of chrysanthemum; F_0, Control; F_1, Wuxol; F_2, Vegimax; F_3: Agro grow and F_4: Surgrow.

Table 2. Combined effect of pinching and foliar application of growth chemicals on number of leaves per plant of chrysanthemum[Y]

Treatments[X]	Number of leaves per plant at							
	20 DAT	30 DAT	40 DAT	50 DAT	60 DAT	70 DAT	80 DAT	90 DAT
P_0F_0	12.6 b	14.0 c	16.0 c	17.0 d	18.6 ef	20.0 de	20.6 e	21.6 d
P_0F_1	16.3 a	18.3 a	20.0 ab	23.3 ab	26.6 abc	27.3 b	28.3 bc	30.0 ab
P_0F_2	17.3 a	19.3 a	21.0 a	24.0 a	26.3 abc	26.3 bc	27.6 bc	29.6 ab
P_0F_3	12.6 b	16.0 b	18.0 bc	20.0 c	22.0 de	23.0 cd	25.0 cd	28.0 bc
P_0F_4	13.6 b	13.6 c	18.3 bc	20.3 bc	22.6 cde	22.6 cd	23.3 de	25.0 cd
P_1F_0	8.3 d	10.6 d	13.6 d	15.3 d	17.6 f	18.3 e	19.6 e	21.0 d
P_1F_1	9.6 cd	11.0 d	17.6 bc	24.3 a	25.3 bcd	28.0 ab	28.6 bc	30.3 ab
P_1F_2	12.3 b	14.0 c	21.3 a	25.3 a	30.3 a	32.0 a	33.0 a	33.6 a
P_1F_3	12.0 bc	13.3 c	19.3 ab	23.6 a	29.3 ab	30.0 ab	31.0 ab	32.0 ab
P_1F_4	11.3 bc	14.3 bc	17.6 bc	23.0 abc	28.3 ab	30.0 ab	31.3 ab	33.3 a
$LSD_{(0.05)}$	2.285	1.786	2.221	2.900	3.884	3.744	3.504	4.398
Significance level	0.01	0.01	0.05	0.05	0.01	0.01	0.01	0.05
CV(%)	10.62	7.25	7.12	7.87	9.22	8.53	7.66	9.06

[X]P_0: Without pinching; P_1: With pinching; F_0: Control; F_1: Wuxol (2.5 ml /L of water); F_2: Vegimax (2.5 ml/L of water); F_3: Agro grow (2.5 ml/L of water); and F_4: Surgrow (2.5 ml/L of water)

[Y]In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

4.1.3 Number of branches per plant

Pinching in chrysanthemum showed significant variation for number of branches per plant at 20, 30, 40, 50, 60, 70, 80 and 90 DAT (Appendix IV). At 90 DAT the maximum number of branches per plant (4.4) was obtained from P_1, whereas, the minimum number of branches per plant (3.4) was found from P_0 for same days after planting, respectively (Figure 5). Similar opinion was also put forwarded earlier by Cheong *et al*. (2006), Ranjit *et al*. (2005), and Beniwal *et al*. (2003) in case of terminal bud pinching.

Number of branches per plant of chrysanthemum differs significantly for different foliar application of growth chemicals at 20, 30, 40, 50, 60, 70, 80 and 90 DAT (Appendix IV). The maximum number of branches per plant (4.8) was observed from F_2. Again, at the same DAT the minimum number of branches per plant (2.6) was recorded from F_0 (Figure 6). Bharmal *et al*. (2005), Gruszczyk and Berbec (2003), Fujii and Sasaki (2000) also reported similar findings earlier from their experiments.

Significant variation was observed for combined effect of pinching and foliar application of growth chemicals in terms of number of branches per plant of chrysanthemum at 20, 30, 40, 50, 60, 70, 80 and 90 DAT (Appendix IV). Maximum number of branches per plant (5.3) was recorded from P_1F_2 at 90 DAT. In an another way, the minimum number of branches per plant (2.3) was found from P_0F_0 at the same days after planting, respectively (Table 3).

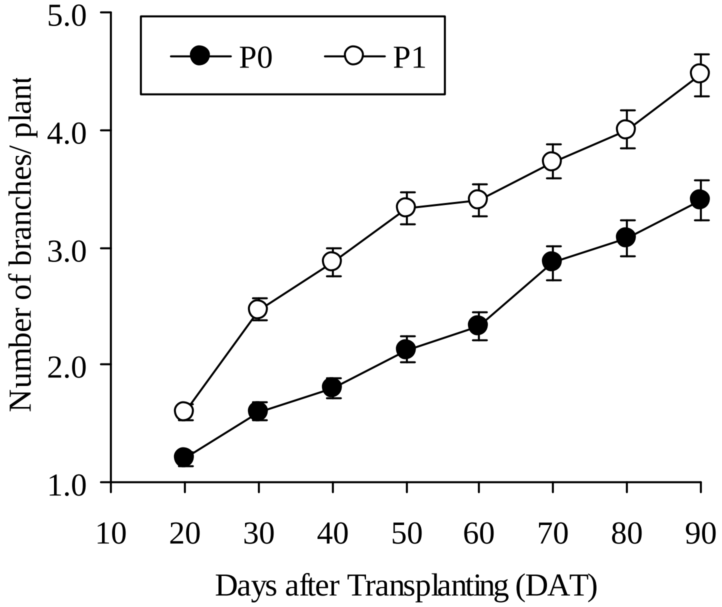

Fig. 5. Effect of pinching on number of branches/plant of chrysanthemum; P_0, Without pinching; P_1, With pinching.

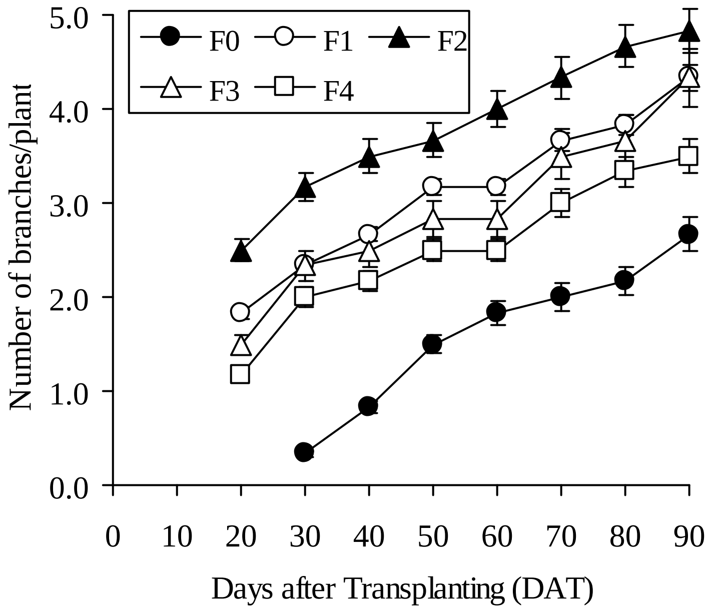

Fig. 6. Effect of foliar application of growth chemicals on number of branches/plant of chrysanthemum; F_0, Control; F_1, Wuxol; F_2, Vegimax; F_3: Agro grow and F_4: Surgrow.

Table 3. Combined effect of pinching and foliar application of growth chemicals on number of branches per plant of chrysanthemum[Y]

Treatments[X]	Number of branches per plant at							
	20 DAT	30 DAT	40 DAT	50 DAT	60 DAT	70 DAT	80 DAT	90 DAT
P_0F_0	0.0 d	0.0 e	0.6 f	1.0 e	1.6 d	2.0 e	2.0 e	2.3 e
P_0F_1	1.6 bc	2.0 bc	2.0 cd	2.3 cd	2.3 cd	3.0 cd	3.0 cd	3.3 cde
P_0F_2	2.0 b	3.0 a	3.0 b	3.3 ab	3.6 ab	4.0 ab	4.3 ab	4.3 abc
P_0F_3	1.3 bc	1.6 c	1.6 de	2.0 d	2.0 d	3.0 cd	3.0 cd	4.0 bcd
P_0F_4	1.0 c	1.3 cd	1.6 de	2.0 d	2.0 d	2.3 de	3.0 cd	3.0 de
P_1F_0	0.0 d	0.6 de	1.0 ef	2.0 d	2.0 d	2.0 e	2.3 de	3.0 de
P_1F_1	2.0 b	2.6 ab	3.3 ab	4.0 a	4.0 a	4.3 ab	4.6 a	5.0 a
P_1F_2	3.0 a	3.3 a	4.3 a	4.0 a	4.3 a	4.6 a	5.0 a	5.3 a
P_1F_3	1.6 bc	3.0 a	3.3 ab	3.6 ab	3.6 ab	4.0 ab	4.3 ab	4.6 ab
P_1F_4	1.3 bc	2.6 ab	2.6 bc	3.0 bc	3.0 bc	3.6 bc	3.6 bc	4.0 bcd
$LSD_{(0.05)}$	0.621	0.762	0.822	0.762	0.880	0.822	0.880	0.933
Significance level	0.05	0.05	0.05	0.01	0.05	0.05	0.05	0.05
CV(%)	6.08	11.99	9.17	6.36	8.01	14.64	11.62	7.93

[X]P_0: Without pinching; P_1: With pinching; F_0: Control; F_1: Wuxol (2.5 ml /L of water); F_2: Vegimax (2.5 ml/L of water); F_3: Agro grow (2.5 ml/L of water); and F_4: Surgrow (2.5 ml/L of water)

[Y]In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

4.1.4 Number of flower buds per plant

Significant difference was observed for cumulative number of flower buds per plant due to the pinching in chrysanthemum at 40, 50, 60, 70, 80, 90, 100 and 110 DAT (Appendix V). At 110 DAT the maximum cumulative number of flower buds per plant (56.4) was found from P_1 and the minimum number of flower buds per plant (44.6) was recorded from P_0 for same DAT, respectively (Figure 7). Brum *et al*. (2007), Cheong *et al*. (2006) and Rakesh *et al*. (2004) also expressed identical findings that they observed in their earlier experiments.

Different foliar application of growth chemicals showed significant differences in cumulative number of flower buds per plant of chrysanthemum at 40, 50, 60, 70, 80, 90, 100 and 110 DAT (Appendix V). The maximum cumulative number of flower buds per plant (57.6) was recorded from F_2. Whereas, at the same DAT the minimum cumulative number of flower buds per plant (8.0) was obtained from F_0, respectively (Figure 8). This type of results also reported by Gruszczyk and Berbec (2004), Karlovic *et al*. (2004), Mahalle *et al*. (2001), Jeong and Kim (2000) earlier by using different growth components as foliar spraying.

Number of flower buds per plant of chrysanthemum showed significant variation for the combined effect of pinching and foliar application of growth chemicals at 40, 50, 60, 70, 80, 90, 100 and 110 DAT (Appendix V). The maximum cumulative number of flower buds per plant (75.4) was found from P_1F_2 at 110 DAT, respectively. Again, the minimum cumulative number of flower buds per plant (27.1) was obtained from P_0F_0 at the same days after planting (Table 4)

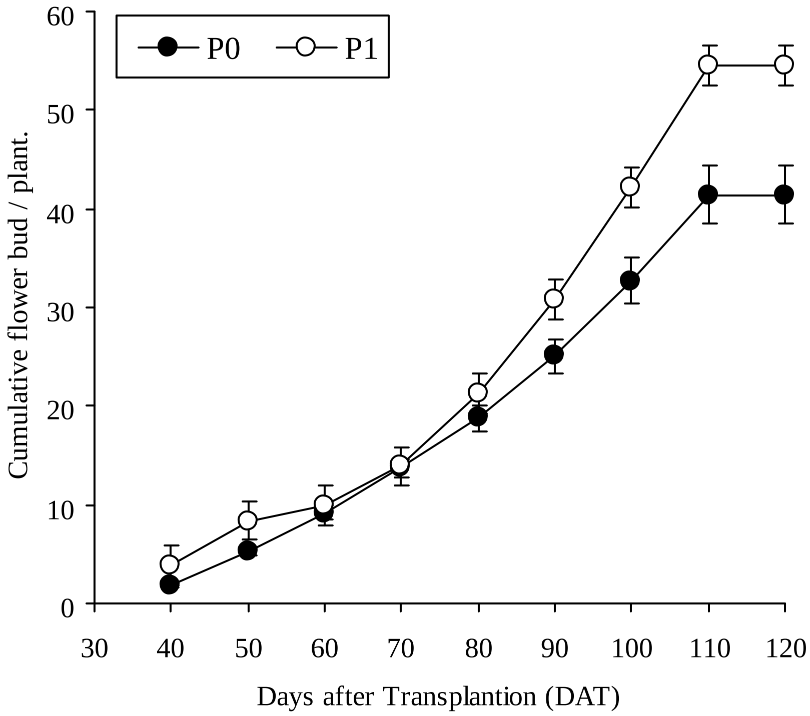

Fig. 7. Effect of pinching on cumulative number of flower buds/plant of chrysanthemum; P_0, Without pinching; P_1, With pinching

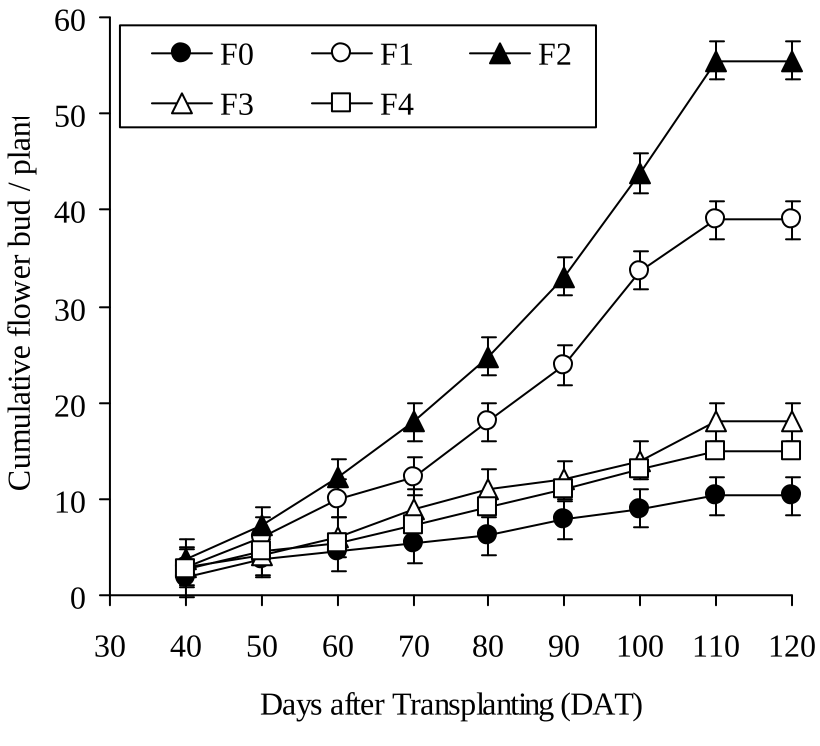

Fig. 8. Effect of foliar application of growth chemicals on cumulative number of flower buds/plant of chrysanthemum; F_0, Control; F_1, Wuxol; F_2, Vegimax; F_3: Agro grow and F_4: Surgrow

Table 4. Combined effect of pinching and foliar application of growth chemicals on number of flower buds per plant of chrysanthemum[Y]

Treatments[X]	Number of flower buds per plant								Cumulative Number of Flower buds/ plant
	40 DAT	50 DAT	60 DAT	70 DAT	80 DAT	90 DAT	100 DAT	110 DAT	
P_0F_0	1.0 e	3.0 e	2.6 d	3.3 e	3.3 e	4.3 e	4.6 d	5.0 d	27.1 e
P_0F_1	2.0 cd	3.6 cde	4.3 c	4.6 d	5.3 d	6.3 d	7.6 c	8.6 c	42.3 d
P_0F_2	2.6 c	4.0 bcd	5.3 b	5.3 cd	6.6 c	8.3 c	10.3 b	12.0 b	54.4 c
P_0F_3	1.6 de	3.6 cde	3.6 cd	4.6 d	5.3 d	6.0 d	7.6 c	8.6 c	40.9 d
P_0F_4	1.6 de	3.3 de	3.3 d	4.3 de	5.0 d	6.3 d	7.6 c	9.0 c	40.4 d
P_1F_0	2.6 c	3.3 de	3.3 d	4.6 d	5.0 d	6.3 d	7.6 c	9.0 c	41.7 d
P_1F_1	4.0 b	4.6 b	5.6 b	7.0 ab	8.3 ab	10.3 b	13.6 a	14.6 a	68.0 b
P_1F_2	5.0 a	5.6 a	6.6 a	8.0 a	8.6 a	12.0 a	14.3 a	15.3 a	75.4 a
P_1F_3	4.0 b	4.6 b	6.0 ab	6.6 b	7.6 abc	9.6 bc	10.6 b	11.6 b	60.6 c
P_1F_4	3.6 b	4.3 bc	5.6 b	6.3 bc	7.3 bc	9.3 bc	10.3 b	11.6 b	58.3 c
$LSD_{(0.05)}$	0.696	0.88	0.933	1.028	1.029	1.586	1.458	1.616	9.226
Significance level	0.05	0.05	0.05	0.05	0.05	0.05	0.01	0.05	0.05
CV (%)	7.41	12.8	11.74	6.01	9.66	11.78	9.05	8.98	6.51

[X]P_0: Without pinching; P_1: With pinching; F_0: Control; F_1: Wuxol (2.5 ml /L of water); F_2: Vegimax (2.5 ml/L of water); F_3: Agro grow (2.5 ml/L of water); and F_4: Surgrow (2.5 ml/L of water)

[Y]In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

4.1.5 Number of flowers per plant

Number of flowers per plant showed significant differences due to pinching in chrysanthemum at 60, 70, 80, 90, 100, 110, 120 and 130 DAT (Appendix VI). Gradually increasing trend of number of flowers per plant was observed with days after transplanting at 130 DAT the maximum cumulative number of flowers per plant (58.7) was obtained from P_1 and the minimum cumulative number of flowers per plant (37.9) was observed from P_0 for same DAT (Figure 9). Sharma *et al*. (2006), Dilta *et al*. (2006), Rakesh *et al*. (2005), Rakesh *et al*. (2003), Sehrawat *et al*. (2003), Jeomg (2000) also reported similar agreement.

Number of flowers per plant of chrysanthemum varied significantly for different foliar application of growth chemicals at 60, 70, 80, 90, 100, 110, 120 and 130 DAP (Appendix VI). The maximum cumulative number of flowers per plant (58.6) was found from F_2. Again, at the same DAT the minimum cumulative number of flowers per plant (32.1) was found from F_0, respectively (Figure 10). Haque *et al*. (2007), Moond *et al*. (2006), Mohariya *et al*. (2003), Gupta and Datta (2001), Kim *et al*. (2000), Farooqi *et al*. (1999) also found same findings.

Combined effect of terminal bud pinching and foliar application in terms of number of flowers per plant of chrysanthemum showed significant variation at 60, 70, 80, 90, 100, 110, 120 and 130 (Appendix VI). The maximum cumulative number of flowers per plant (83.3) was obtained from P_1F_2 at 130 DAT, respectively. Again, the minimum cumulative number of flowers per plant (25.3) was obtained from P_0F_0 at the same days after planting (Table 5).

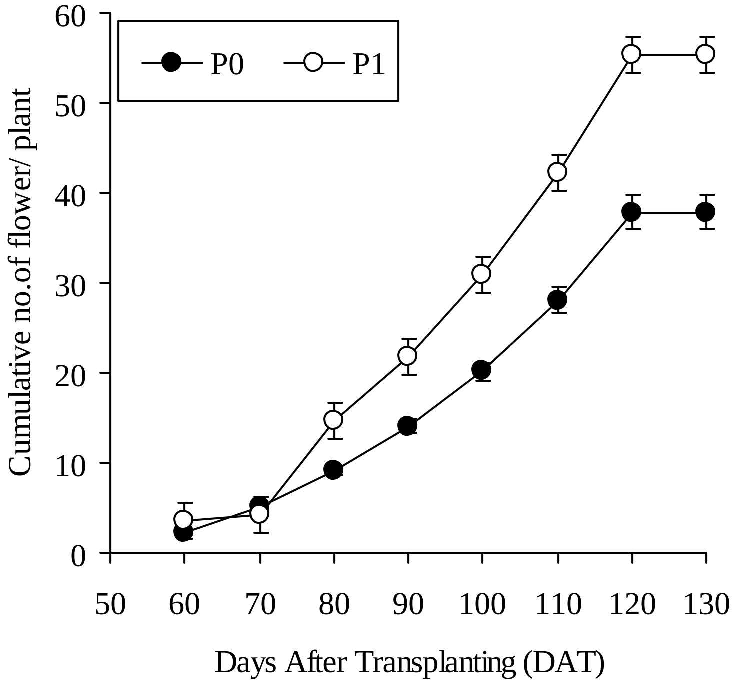

Fig. 9. Effect of pinching on cumulative number of flower/plant of chrysanthemum; P_0, Without pinching; P_1, With pinching

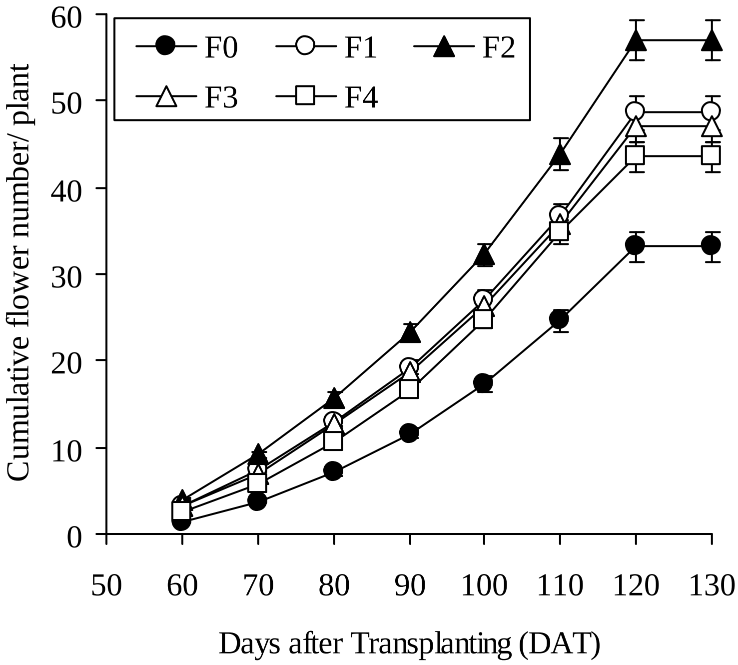

Fig. 10. Effect of foliar application of growth chemicals on cumulative number of flower/plant of chrysanthemum; F_0, Control; F_1, Wuxol; F_2, Vegimax; F_3: Agro grow and F_4: Surgrow

Table 5. Combined effect of pinching and foliar application of growth chemicals on number of flowers per plant of chrysanthemum[Y]

Treatments[X]	Number of flowers per plant at								Cumulative number of flowers/Plant
	60 DAT	70 DAT	80 DAT	90 DAT	100 DAT	110 DAT	120 DAT	130 DAT	
P_0F_0	1.0 f	1.6 e	2.6 f	3.0 d	3.3 e	4.00 d	4.6 f	5.0 e	25.3 f
P_0F_1	2.6 cd	3.3 cd	4.3 e	5.3 bc	6.6 cd	8.3 c	10.6 de	11.0 cd	52.3 de
P_0F_2	3.0 c	3.6 c	4.6 de	5.6 bc	7.0 cd	10.0 bc	11.6 bcde	12.3 bcd	58.0 cde
P_0F_3	2.3 de	3.0 cd	4.6 de	5.0 c	6.3 d	8.0 c	10.0 e	10.6 d	50.0 e
P_0F_4	2.0 e	2.6 d	4.3 e	5.3 bc	7.0 cd	9.3 bc	11.3 cde	12.0 bcd	54.0 de
P_1F_0	2.0 e	3.0 cd	4.0 e	6.0 bc	8.0 bc	10.6 b	12.3 bcd	13.0 abc	59.0 cd
P_1F_1	4.0 b	5.0 b	6.6 bc	7.0 b	9.0 b	11.0 b	13.3 ab	13.6 ab	69.6 b
P_1F_2	5.0 a	6.6 a	8.3 a	9.3 a	11.0 a	13.3 a	14.6 a	15.0 a	83.3 a
P_1F_3	4.0 b	4.6 b	7.0 b	7.0 b	8.6 b	11.0 b	12.6 bc	13.3 ab	68.3 b
P_1F_4	3.0 c	3.6 c	5.6 cd	6.6 bc	9.0 b	11.0 b	12.0 bcd	12.3 bcd	63.3 bc
$LSD_{(0.05)}$	0.441	0.822	1.032	1.492	1.458	1.891	1.759	1.917	7.579
Significance level	0.01	0.05	0.05	0.05	0.05	0.05	0.01	0.01	0.01
CV%)	8.90	12.94	11.57	14.51	11.27	8.49	6.11	9.51	7.63

[X]P_0: Without pinching; P_1: With pinching; F_0: Control; F_1: Wuxol (2.5 ml /L of water); F_2: Vegimax (2.5 ml/L of water); F_3: Agro grow (2.5 ml/L of water); and F_4: Surgrow (2.5 ml/L of water)

[Y]In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

4.1.6 Days to bud initiation

Days to bud initiation in chrysanthemum showed significant variation due to pinching (Appendix VII). The maximum days to bud initiation (32.8) was found from P_1 and the minimum days (27.3) was recorded from P_0 (Table 6). Similar opinion was also put forwarded by Khandelwal *et al*. (2003) and Yoo *et al*. (1999) also recorded similar results.

Different foliar application showed significant variation in terms of days to bud initiation of chrysanthemum (Appendix VII). The maximum days to bud initiation (33.6) was recorded from F_0 which was closely followed (30.5 and 30.1) by F_4 and F_3. Again, the minimum days (27.3) was obtained from F_2 which was statistically identical (28.6) with F_1 (Table 7). Mohariya *et al*. (2003) reported identical findings by using different growth components.

Pinching and foliar application of growth chemicals showed significant variation for combined effect in terms of days to bud initiation of chrysanthemum (Appendix VII). The maximum days to bud initiation (38.0) was recorded from P_1F_0 and the minimum days (25.3) was recorded from P_0F_2 (Table 8).

4.1.7 Days to flower initiation

Significant difference was observed for days to flower initiation due to pinching in chrysanthemum (Appendix VII). The maximum days to flower initiation (31.8) was recorded from P_1 and the minimum days (28.4) was observed from P_0 (Table 6). Rakesh *et al*. (2005), Chavan *et al*. (2004) reported similar findings.

Days to flower initiation of chrysanthemum showed significant variation for different foliar application of growth chemicals (Appendix VII). The maximum days to flower initiation (33.8) was recorded from F_0 which was closely followed (30.3) by F_1. Again, the minimum days (27.5) was found from F_4 which was statistically identical (29.8 and 29.3) with F_2 and F_3 (Table 7). Kim *et al*. (2001), Kwon *et al*. (2001), Sharad *et al*. (2000) and Meher *et al*. (1999) recorded similar results by using different growth components.

Table 6. Effect of pinching on days to bud initiation & flowering, flower durability and color parameter of chrysanthemum[X]

Treatments	Days to bud initiation		Days to flower initiation		Flower durability in plant		[Z] Coloration				
							L*	a*	b*	c*	h_{ab}
P_0	27.3	b	28.5	b	17.9	a	81	17	18	30.0	129.67
P_1	32.8	a	31.9	a	16.7	b	75	23	14	33.3	98.64
LSD $_{(0.05)}$	1.3		1.6		0.68		--	--	--	--	--
Significance level	0.0		0.0		0.01		NS	NS	NS	NS	NS

[X] In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

[Y] P_0, Without pinching; P_1, With pinching

[Z] L*, Lightness; a* and b*, chromatic components; and C*, chromas (brightness), hab, hue angle (degree) = tang (b*/a*)

Table 7. Effect of foliar application on days to bud initiation & flowering, flower durability and color parameter of chrysanthemum [X]

[Y] Treatments	Days to bud initiation		Days to flower initiation		Flower durability in plant		[Z] Coloration				
							L*	a*	b*	c*	h_{ab}
F_0	33.7	a	33.8	a	19.0	a	88	10	6	14.37 b	164.5
F_1	28.7	bc	30.3	b	15.8	bc	72	23	29	50.17 a	107.5
F_2	27.3	c	29.8	bc	16.8	b	86	9	16	20.73 b	114.6
F_3	30.2	b	29.3	bc	19.5	a	75	28	14	38.07ab	90.6
F_4	30.5	b	27.5	c	15.5	c	68	29	16	34.67ab	93.7
LSD $_{(0.05)}$	2.0		2.5		1.1		-	-	-	-	-
CV%)	5.6		7.0		5.2		NS	NS	NS	NS	NS

[X] In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

[Y] F_0: Control, F_1: Wuxol (2.5 ml /L of water); F_2: Vegimax (2.5 ml/L of water) F_3: Agro grow (2.5 ml/L of water) and F_4: Surgrow (2.5 ml/L of water)

[Z] L*, Lightness; a* and b*, chromatic components; and C*, chromas (brightness), hab, hue angle (degree) = tang (b*/a*)

Combined effect of pinching and foliar application of growth chemicals of chrysanthemum showed significant variation for days to flower initiation (Appendix VII). The maximum days to flower initiation (35.0) was recorded from P_1F_0 and the minimum days (23.3) was obtained from P_0F_4 (Table 8).

4.1.8 Flower durability in plant

Significant variation was recorded for flower durability in plant due to the terminal bud pinching in chrysanthemum (Appendix VII). The highest flower durability in plant (17.9 days) was observed from P_0 and the lowest (16.7 days) was observed from P_1 (Table 6). Similar agreement also expressed by Chavan *et al*. (2004), Pal and Biswas (2004), Khandelwal *et al*. (2003).

Flower durability in plant of chrysanthemum showed significant variation for different foliar application of growth chemicals (Appendix VII). The highest flower durability in plant (19.5 days) was recorded from F_3 which was statistically identical (19.0 days) with F_0. Again, the lowest (15.5 days) was recorded from F_4 which was closely followed (15.8 days and 16.8 days) by F_1 and F_2 (Table 7). Similar opinion was also put forwarded by Shima *et al*. (2004).

Combined effect of terminal bud pinching and foliar application of growth chemicals in terms of flower durability in plant of chrysanthemum showed significant variation (Appendix VII). The highest flower durability in plant (20.6 days) was found from P_0F_3 and the lowest days (14.6 days) was obtained from P_1F_4 (Table 8).

4.1.9 Petal coloration

Pinching showed non-significant variation al the parameters in terms of the petal coloration (h_{ab}, L*, a*, b*, c*) (Appendix VII). Highest (129.67) hue angle (h_{ab}) was recorded from P_0 and the lowest (98.64) hue angle ($h_{ad},$) was recorded from P_1. Highest (81) L* was recorded from P_0 and lowest (75) L* was obtained from P_1. Highest (23) a* was recorded from P_1 and the lowest (17) a* was obtained from P_0. The highest (18) b* was recorded from P_0 and the lowest (14) b* was obtained from P_1. The highest (33.25) c* was recorded from P_1 and the lowest (29.95) c* was obtained from P_0 (Table 6).

Table 8. Combined effect of terminal bud pinching and foliar application of growth chemicals on days to bud initiation & flowering, flower durability and color parameter of chrysanthemum

Treatments	Days to bud initiation		Days to flower initiation		Flower longevity in plant		Coloration[z]				
							L*	a*	b*	c*	h_{ab}
P_0F_0	29.3	c	32.7	ab	19.0	b	85	14	2	14.5	242.6
P_0F_1	27.7	cd	28.0	c	15.7	c	72	21	31	48.8	49.5
P_0F_2	25.3	d	30.3	bc	18.0	b	90	4	16	19.5	169.5
P_0F_3	26.7	cd	28.0	c	20.7	a	82	21	22	38.0	145.9
P_0F_4	27.7	cd	23.3	d	16.3	c	74	22	19	29.0	40.8
P_1F_0	38.0	a	35.0	a	19.0	b	91	6	11	14.3	86.3
P_1F_1	29.7	c	32.7	ab	16.0	c	72	24	27	51.6	165.5
P_1F_2	29.3	c	29.3	bc	15.7	c	82	14	15	22.0	59.6
P_1F_3	33.7	b	30.7	bc	18.3	b	68	35	5	38.1	35.3
P_1F_4	33.3	b	31.7	abc	14.7	c	62	36	12	40.3	146.6
LSD $_{(0.05)}$	2.9		3.6		1.5		-	-	-	-	-
CV %	5.6		7.0		5.2		NS	NS	NS	NS	NS

[X] In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

[Y] P_0, Without pinching; P_1, With pinching, F_0: Control, F_1: Wuxol (2.5 ml /L of water); F_2: Vegimax (2.5 ml/L of water) F_3: Agro grow (2.5 ml/L of water) and F_4: Surgrow (2.5 ml/L of water)

[Z] L*, Lightness; a* and b*, chromatic components; and C*, chromas (brightness), hab, hue angle (degree) = tang (b*/a*)

Foliar application of growth chemicals showed non-significant all the parameters in terms of the petal coloration ($h_{ab,}$ L*, a*, b*, c*) except c* (Appendix VII). Highest (164.5) hue angle (h_{ab}) *was* recorded from F_0 and lowest (90.6) hue angle (*hab*) was recorded from F_3. Highest (88) L* was recorded from F_0 and the lowest (68) L* was obtained from F_4. Highest (29) a* was found from F_4 and lowest (9) a* was obtained from F_2. Highest (29) b* was recorded from F_1 and lowest (6) b* was obtained from F_0. Highest (50.17) c* was observed from F_1 and the lowest (14.37) c* was obtained from F_0 (Table 7).

Interaction between pinching and foliar application of growth chemicals on the petal coloration was found to be significant. The highest (242.6) hue angle (h_{ab}) was recorded from P_0F_0 and lowest (35.3) hue angle (h_{ab}), was obtained from P_1F_3. Highest (91) L* was recorded from P_1F_0 and lowest (62) L* was obtained from P_1F_4. Highest (36) a* was recorded from P_1F_4 and lowest (4) a* was obtained from P_0F_2. Highest (31) b* was recorded from P_0F_1 and lowest (2) b* was obtained from P_0F_0. Highest (48.8) c* was recorded from P_0F_1 and lowest (14.3) c* was obtained from P_1F_0 (Table 8).

4.2 Discussion

In the process of pinching the terminal bud was removed from the plants that attained a stress condition and plant required a few time to overcome this condition and the growth was hampered. On the other hand in case of without pinching plant exhibits it normal vegetative growth without any stress. For that due to pinching plant cannot accomplish vegetative growth and the ultimate results was the shortest plant compared to the without pinching of terminal bud (P_0) because without pinching terminal bud helps to attained optimum vegetative growth without disruption of normal plant growth of chrysanthemum. Pinching leads to development of new branches in addition of number and the ultimate results was the maximum number of branches as well as flower buds and finally maximum number of flowers.

Among the different foliar application of growth chemicals Vegimax (F_2) content N, P, K, S, Zn, B, Cu, Mn, Fe, Mo, Cl, vitamin and amino acids and Wuxol (F_1) content also N, P, K and other micronutrients in liquid and available form, so it is a balance nutrient mixture for vigorous and healthy plant growth. On the other hand, agrogrow (F_3) and surgrow (F_4) though both are also growth hormone that helps to vegetative growth and also attaining maximum number of buds and flowers per plant. But among the foliar application that used in this study Vegimax was superior considering others.

When pinching was done with additional foliar application that attained the highest production of quality flower with highest vegetative growth. All the foliar application helps to increased production but the application of Vegimax and Wuxol were most effective for better and quality yield of chrysanthemum and it would be economically benefited.

CHAPTER V
SUMMARY AND CONCLUSION

There has been a slow progress in chrysanthemum production in our country due to lack of information which serve as guides in development of technology for profitable production. Farmers still practice the traditional method of the crop, resulting in low production and poor quality of flower. Improvement of chrysanthemum production depends upon soil and climatic condition as well as cultural practice of maintaining the proper management. In order to maximize the better production of chrysanthemum through terminal bud pinching and foliar application, an experiment was conducted to investigate the on growth, coloration and yield of chrysanthemum at the Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka during the period from October 2008 to March 2009. Experiment included terminal bud pinching viz. P_0: without pinching and P_1: with pinching and different foliar application of growth chemicals viz. F_0: No foliar application viz. F_1: Wuxol (2.5 ml/l); F_2: Vegimax (2.5 ml/ l); F_3: Agro grow (2.5 ml/ l) and F_4: Surgrow (2.5 ml/ l). The two factor experiment was laid out in a Complete Randomized Design (CRD) with three replications. Size of the each pot was 20 cm × 18 cm. Seedlings were planted on 17 October, 2008.

Data were taken for plant height (cm), number of leaves per plant, number of branches per plant, number of flower buds per plant, number of flowers per plant, days to bud initiation, days to flower initiation, flower durability and petal coloration (h_{ab}, L*, a*, b*, c*). Collected data were statistically analyzed for evaluation of the treatments effect. Summary of the results and conclusion have been described in this chapter.

Influence of pinching, foliar application of growth chemicals and their interaction, in respect of the coloration, yield and yield contributing character were found to be significant. At 90 DAT the tallest plant (37.7 cm) was recorded from P_0 and the shortest plant (33.4 cm) was found from P_1 for same DAT, respectively. At 90 DAT the maximum number of leaves per plant (30.1) was recorded for P_1, while the minimum (26.8) was obtained from P_0. At 90 DAT the maximum number of branches per plant (4.4) was obtained from P_1 and the minimum number (3.4) was found from P_0 for same DAT, respectively. At 110 DAT the maximum number of flower buds per plant (56.4) was found from P_1 and the minimum number (44.6) was recorded from P_0 for same DAT, respectively. At 130 the maximum number of flowers per plant (58.7) was obtained from P_1 and the minimum number (37.9) was observed from P_0 for same DAT, respectively. The maximum days to bud initiation (32.8) was found from P_1 and the minimum days (27.3) was recorded from P_0. The maximum days to flower initiation (31.8) was recorded from P_1 and the minimum days (28.4) was observed from P_0. The highest flower longevity in plant (17.9 days) was observed from P_0 and the lowest (16.7 days) was observed from P_1.

At 90 DAT the tallest plant (38.2 cm) was recorded from F_2 again, at the same DAT the shortest plant (31.4 cm) was found from F_0, respectively. At 90 DAT, the maximum number of leaves per plant (31.6) was observed from F_2 and at the same DAT the minimum number (21.3) was recorded from F_0, respectively. At the 90 DAT, the maximum number of branches per plant (24.8) was observed from F_2 and at the same DAT the minimum number (2.6) was recorded from F_0, respectively. At 110 DAT the maximum number of flower buds per plant (57.6) was recorded from F_2 and at the same DAT the minimum number (8.0) was obtained from F_0, respectively. At 130 DAT the maximum number of flowers per plant (58.6) was found from F_2 whereas at the same DAT the minimum number (32.1) was found from F_0, respectively. The maximum days to bud initiation (33.6) was recorded from F_0 which was closely followed (30.5 and 30.1) by F_4 and F_3. Again, the minimum days (27.3) was obtained from F_2. Maximum days to flower initiation (33.8) were recorded from F_0 which was closely followed (30.3) by F_1. Again, the minimum days (27.5) was found from F_4. Highest flower longevity in plant (19.5 days) was recorded from F_3 again the lowest (15.5 days) was recorded from F_4.

The tallest plant (43.2 cm) was recorded from P_0F_2 at 90 DAT. On the other hand, the shortest plant (30.6 cm) was obtained from P_1F_0 at the same days after planting. At 90 DAT the maximum number of leaves per plant (33.6) was recorded from P_1F_2. On the other hand, the minimum number (21.0) was recorded from P_1F_0 at the same days after planting, respectively. The maximum number of branches per plant (5.3) was recorded from P_1F_2 at 90 DAT. On the other hand, the minimum number (2.3) was found from P_0F_0. The maximum number of flower buds per plant (75.4) was found from P_1F_2 at 110 DAT. On the other hand, the minimum number (27.1) was obtained from P_0F_0 at the same days after planting, respectively. The maximum number of flowers per plant (83.3) was obtained from P_1F_2 at 130 DAT. On the other hand, the minimum number (25.3) was obtained from P_0F_0. The maximum days to bud initiation (38.0) was recorded from P_1F_0 and the minimum days (25.3) was recorded from P_0F_2. The maximum days to flower initiation (35.0) was recorded from P_1F_0 and the minimum days (23.3) was obtained from P_0F_4. The highest flower longevity in plant (20.6 days) was found from P_0F_3 and the lowest days (14.6 days) was obtained from P_1F_4.

Highest (129.67) hue angle (h_{ab}) was recorded from P_0 and the lowest (98.64) hue angle (h_{ad},) was recorded from P_1. Highest (81) L* was recorded from P_0 and lowest (75) L* was obtained from P_1. Highest (23) a* was recorded from P_1 and the lowest (17) a* was obtained from P_0. The highest (18) b* was recorded from P_0 and the lowest (14) b* was obtained from P_1. The highest (33.25) c* was recorded from P_1 and the lowest (29.95) c* was obtained from P_0. Highest (164.5) hue angle (h_{ab}) *was* recorded from F_0 and lowest (90.6) hue angle (*hab*) was recorded from F_3. Highest (88) L* was recorded from F_0 and the lowest (68) L* was obtained from F_4. Highest (29) a* was found from F_4 and lowest (9) a* was obtained from F_2. Highest (29) b* was recorded from F_1 and lowest (6) b* was obtained from F_0. Highest (50.17) c* was observed from F_1 and the lowest (14.37) c* was obtained from F_0.The highest (242.6) hue angle (h_{ab}) was recorded from P_0F_0 and lowest (35.3) hue angle (h_{ab}), was obtained from P_1F_3. Highest (91) L* was recorded from P_1F_0 and lowest (62) L* was obtained from P_1F_4. Highest (36) a* was recorded from P_1F_4 and lowest (4) a* was obtained from P_0F_2. Highest (31) b* was recorded from P_0F_1 and lowest (2) b* was obtained from P_0F_0. Highest (48.8) c* was recorded from P_0F_1 and lowest (14.5) c* was obtained from P_1F_0.

Conclusion

Pinching (P_1) with Vegimax (F_2) was most suitable for growth, coloration and yield of chrysanthemum.

Considering the findings of the present experiment, further studies in the following areas may be suggested:

i. Study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability.
ii. Other different combination of pinching and foliar application of growth chemicals may include for further studied.

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APPENDICES

Appendix I. Monthly record of air temperature, relative humidity and rainfall of the experimental site during the period from October 2008 to March, 2009

Month	*Air temperature (^oC)		*Relative humidity (%)	*Rain fall (mm) (total)
	Maximum	Minimum		
October, 2008	33.5	26.4	85	45
November, 2008	25.8	16.04	78	00
December, 2008	22.4	13.5	74	00
January, 2009	24.5	12.4	68	00
February, 2009	27.1	16.7	67	30
March, 2009	31.4	19.6	54	11

* Monthly average,

* Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka - 1212

Appendix II. Analysis of variance of the data on plant height as influenced by pinching and foliar application of growth chemicals on chrysanthemum

Source of variation	Degrees of freedom	Mean square						
		Plant height (cm) at						
		20 DAP	30 DAP	40 DAP	50 DAP	60 DAP	70 DAP	80 DAP
Pinching (A)	1	133.563**	51.745**	88.752**	79.381**	101.936**	88.752**	123.221**
Foliar application of growth chemicals (B)	4	14.140**	12.003**	21.374**	34.791**	39.591**	36.644**	39.830**
Interaction (A×B)	4	10.266*	4.871*	4.036*	3.772*	4.434*	11.032**	16.800*
Error	20	3.219	1.625	1.165	1.229	1.434	2.641	5.672

** Significant at 0.01 level of probability, * Significant at 0.05 level of probability

Appendix III. Analysis of variance of the data on number of leaves per plant as influenced by pinching and foliar application of growth chemicals on chrysanthemum

Source of variation	Degrees of freedom	Mean square						
		Number of leaves per plant at						
		20 DAP	30 DAP	40 DAP	50 DAP	60 DAP	70 DAP	80 DAP
Pinching (A)	1	108.300**	97.200**	4.033	14.700*	64.533**	108.300**	104.533**
Foliar application of growth chemicals (B)	4	14.450**	12.283**	28.367**	65.950**	88.717**	89.383**	91.617**
Interaction (A×B)	4	8.217**	15.783**	6.700*	6.117*	23.117**	24.717**	22.450**
Error	20	1.800	1.100	1.700	2.900	5.200	4.833	4.233

** Significant at 0.01 level of probability, * Significant at 0.05 level of probability

Appendix IV. Analysis of variance of the data on number of branches per plant as influenced by pinching and foliar application of growth chemicals on chrysanthemum

Source of variation	Degrees of freedom	Mean square							
		Number of branches per plant							
		20 DAP	30 DAP	40 DAP	50 DAP	60 DAP	70 DAP	80 DAP	90 DAP
Pinching (A)	1	1.200**	5.633**	8.533**	10.800**	8.533**	5.633**	6.533**	8.533**
Foliar application of growth chemicals (B)	4	5.133**	6.533**	5.667**	3.967**	3.867**	4.533**	4.950**	4.383**
Interaction (A×B)	4	0.900*	0.800*	0.867*	0.700**	1.533*	0.967*	0.950*	0.950*
Error	20	0.133	0.200	0.202	0.200	0.267	0.233	0.267	0.300

** Significant at 0.01 level of probability, * Significant at 0.05 level of probability

Appendix V. Analysis of variance of the data on number of flower buds per plant as influenced by pinching and foliar application of growth chemicals on chrysanthemum

Source of variation	Degrees of freedom	Mean square							
		Number of flower buds per plant							
		40 DAP	50 DAP	60 DAP	70 DAP	80 DAP	90 DAP	100 DAP	1
Pinching (A)	1	32.033**	7.500**	19.200**	32.033**	38.533**	80.033**	104.533**	1
Foliar application of growth chemicals (B)	4	3.083**	2.200**	7.083**	5.667**	10.133**	17.883**	31.283**	3
Interaction (A×B)	4	0.117	0.833*	0.883*	0.767*	0.967*	1.950*	2.783*	2
Error	20	0.167	0.267	0.300	0.367	0.367	0.867	0.733	0

** Significant at 0.01 level of probability, * Significant at 0.05 level of probability

Appendix VI. Analysis of variance of the data on number of flowers per plant as influenced by pinching and foliar application of growth chemicals on chrysanthemum

Source of variation	Degrees of freedom	Mean square							
		Number of flowers per plant							
		60 DAP	70 DAP	80 DAP	90 DAP	100 DAP	110 DAP	120 DAP	1 D
Pinching (A)	1	14.700**	22.533**	36.300**	40.833**	70.533**	90.133**	83.333**	8
Foliar application of growth chemicals (B)	4	5.383**	6.800**	8.550**	6.783**	8.883**	14.583**	17.917**	1
Interaction (A×B)	4	0.283**	0.867*	1.383*	2.417*	2.117*	5.383**	10.083**	1
Error	20	0.067	0.233	0.367	0.767	0.733	1.233	1.067	1

** Significant at 0.01 level of probability, * Significant at 0.05 level of probability

Appendix VII. Analysis of variance of the data on days to bud initiation & flowering and flower durability and color parameter as influenced by pinching and foliar application of growth chemicals on chrysanthemum

Source of variation	Degrees of freedom	Mean square							
		Days to bud initiation	Days to flower initiation	Flower longevity in plant	L*	a*	b*	c*	*
Pinching (A)	1	224.133**	86.700**	10.800**	224.133	307.200	112.133	82.005	72
Foliar application of growth chemicals (B)	4	33.883**	32.083**	20.000**	465.450	541.867	395.000	1216.523*	53
Interaction (A×B)	4	10.050*	17.617*	2.467*	96.883	130.200	131.967	33.029	25
Error	20	2.800	4.433	0.800	365.800	550.167	395.200	421.009	17

** Significant at 0.01 level of probability, * Significant at 0.05 level of probability