A SEMINAR PAPER ON

Cut flower and Foliage Plant Production as Influenced by Plant Growth Regulators

Course Title: Seminar

Course Code: HRT 598

Winter, 2017

SUBMITTED TO:

Course Instructors	Major Professor
1. Prof. Dr. A. K. M. Aminul Islam Department of GPB BSMRAU, Gazipur 2. Dr. Md. Abdullahil Baki Bhuiyan Assistant Professor Department of Plant Pathology BSMRAU, Gazipur	Md. Shyduzzaman Roni Assistant Professor Department of Horticulture BSMRAU, Gazipur

SUBMITTED BY:

Nazma Akter
MS Student
Reg. No.: 16-11-4147
Department of Horticulture

BANGABANDHU SHEIKH MUJIBUR RAHMAN AGRICULTURAL UNIVERSITY

SALNA, GAZIPUR 1706

Cut Flower and Foliage Plant Production as Influenced by Plant Growth Regulators

Nazma Akter

ABSTRACT

Floriculture is a fast emerging and highly competitive industry. Ornamental crop culture technology is improving with the availability of equipment and there is a sea change in the trend of consumers. Plant growth regulators consist of a large group of naturally occurring or synthetically produced organic chemicals and considered as helping tool in the modern production system of ornamentals. Their exogenous application helps to improve the different economically important and market desirable characteristics of ornamental plants. The use of plant growth regulators is being practiced by the commercial growers of ornamental plants as a part of cultural practice. There are various factors contributing to the efficacy of plant growth regulators and the method of application plays key role in determining the effectiveness of plant growth regulators, as PGRs can be effective if properly absorbed by plants. There are various methods of application of PGRs but the most popular are foliar sprays, drenching and pre-plant soaking while the efficacy of each method depends on the various factors including the mode of absorption of PGRs by different plant parts, method of application and environmental factors.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURE

LIST OF PLATES

CHAPTER I

1.0 INTRODUCTION

Floriculture has become a lucrative industry and emerged as a challenging profession with a much higher potential for returns than most and some horticultural crops (Chopra, 1994). Cut flower and foliage plants are the important segments of floriculture industry. Cut flowers refers to flowers starting to blossom or flower buds that are cut with branches, stems and leaves to be used for bouquets or decorations. Flowers having long and stout stalk and prolong vase life are considered as cut flower which constitute 45% share of the total world trade in floricultural products (Dadlani, 2003). At present the annual consumption of cut flowers in the world is worth $13,000 million (Gauchan, 2009). Foliage plants are those which are cultivated with the main aim of being marketed and used for decorative purposes. Planted outdoors, they improve our environment, while in indoor use they contribute to our health, well being and creativity. The commercial importance of cut flower and foliage plants has been realized through out the world. Economics and marketing studies indicate that the consumption of cut flower and foliage crops increases in proportion with the standard of living of the populations.

Flowers are embedded in the culture of Bangladesh. The production of flowers as well as floriculture products and thei uses have been practiced in our country for centuries . At present it is not only being recognized as a symbol of purity and beauty, but also a potential revenue earner .Bangladesh has advantage due to its favourable climate, topography, lower labour cost and relatively low production cost for growing many cut flower and foliage plants which can help the development of flower industry. Cut flower development has brought a dramatic increase of the farmer's income in Bangladesh. Flower trading worth of Tk 51.5 million has been recorded at Godkhali flower market Jhikargacha, Jessore simply on the occasion of spring festival and valentine day during 2013 (Islam, 2013). This is the testimony of booming flower market in Bangladesh. At present, flower cultivation has adopted commercially in 19 Zillas (districts) out of 64 of our country (Khan, 2013). Besides cut flower, foliage plants are also gaining importance for floriculture trade. At present, some farmers are producing various foliage plants commercially to meet the market demand. As most of the important cut flower and foliage plants are native to tropical regions, these can be successfully grown in Bangladesh. According to Campo (2001), Bangladesh has very good potentialities to become an important supplier of cut flowers and foliage plants for Asia, the Middle East and Europe. There are bright prospects for earning substantial foreign exchange through export of cut flowers and foliage plants after meeting the internal needs. This sector has influenced the national GDP growth as well as employment generation in Bangladesh. So, commercial flower production is a profitable venture which can contribute to boost up the national economy of Bangladesh. But the low quality and yield is the main problem for the production of cut flower and foliage plants those are due to low seed germination, lower plant growth and development, late flowering, shortens vase life and early senescence etc.

Now-a-day the use of plant growth regulators (PGR) is getting popularity in crop production around the world. PGR are chemical compounds that alter plant growth and development by modifying natural hormonal action. The role of plant growth regulators in various physiological and biochemical process in plant is well known and when it is applied in plants it influences their growth and development (Randhawa, 1971). Cut flower and foliage plants find extensive use of growth regulators for modifying their developmental processes. The major areas where growth regulators have successfully played their roles in cut flower and foliage plants are in dormancy breaking, growth promotion and retardation, flowering, rooting, retarding their senescence and prolonging the vase life of flowers. So, use of plant growth regulators provides immense opportunities to increase the production of cut flowers and foliage plants.

Many technologies are available for the production of cut flowers and foliage plants, but information regarding the use of plant growth regulators in Bangladesh is very scanty. Therefore, this paper reviewed the research work done in the developed countries as well as developing countries on the use of various growth regulators in cut flowers and foliage plant production with the following objectives.

1. To identify the possible areas of application of plant growth regulators for cut flowers and foliage plant production.
2. To identify suitable plant growth regulators as per requirements.
3. To increase the quality and yield of flowering and foliage plants.

CHAPTER II

2.0 MATERIALS AND METHODS

The topic of my seminar paper was selected with the consultation of my Major professor. This paper is exclusively a review paper. So, for preparing this manuscript, all of the information has been collected from the secondary sources. During the preparation of this paper, I collected key information from various relevant books, journals, proceedings, reports, publications etc. Findings related to my topic have been reviewed with the help of the library facilities of Bangabandhu Sheikh Mujibur Rahman Agricultural University. I have also collected information by searching related internet web sites. I got valiable suggestion and information from my course instructors, my major professor and other resource personal .After collecting all the information. I compiled and prepared this seminar paper.

CHAPTER III

3.0 REVIEW OF LITERATURE

3.1 Cut flowers and foliage plants

There are various cut flowers and foliage plants available in Bangladesh those have commercial importance.

Table 1.List of cut flowers and foliage plants

Cut flowers	Foliage plants
Gladiolus	Caladium
Tuberose	Aglaonema
Rose	Aralia
Gerbera	Spider plant
Chrysanthemum	Diffenbanchia
Marigold	Coleus
Carnation	Cordyline
Anthurium	Crotons
Dahlia	Ficus
Zinnia	Palm
Orchids	Dracaena

3.2 Classification of plant growth regulators

There are six major classes of plant growth regulators according to the American Society for Horticultural Science (Table 2).

Table 2. Classes and functions of plant growth regulator

Class	Function (s)
Auxins	Shoot elongation
Gibberellins	Stimulate cell division and elongation
Cytokinins	Stimulate cell division
Ethylene generators	Hastens senescence
Growth inhibitors	Stops growth
Growth retardants	Slows growth

Source: Fishel, (2007)

3.3 Use of plant Growth regulators

Plant growth regulators are not highly specific in their action and affect a variety of growth and developmental processes in the plant. Sometimes there are many overlapping and interacting effects of growth regulators in cut flower and foliage plants. However, the uses of some plant growth regulators in cut flower and foliage plants production are described below.

3.3.1 Dormancy

Plant growth regulators can be successfully used in breaking dormancy. Freshly harvested corms, cormels and bulbs of some cut flowers undergo a period of dormancy which is regulated by changes in the levels of endogenous promontory or inhibitory substances (Misra and singh, 1998). Dormancy is more pronounced in cormels and bulblets than corms and bulbs. A cytokinin (BA) and ethylene (ethrel) play a role in breaking dormancy of gladiolus cormels (Table 3).

Table 3. Effect of BA and Ethrel on breaking dormancy in gladiolus cormels cv. Friendship

Treatments (ppm)	Percentage of sprouting	Days taken for 50% sprouting
BA 25	50.00	50.25
BA 50	55.00	45.00
BA 100	90.00	42.00
BA 150	80.12	50.10
Ethrel 100	42.12	46.12
Ethrel 150	88.00	45.00
Ethrel 200	75.00	50.00
Ethrel 250	68.00	52.00
Control	40.00	70.00
C.D. at 1%	1.27	0.81

Source: Narayana and Gowda, (1994)

3.3.2 Seed Germination

When seeds are sown in the fields germinated under favorable condition if the seeds are not dormant. But due to physical, physiological or environmental factors, seeds may not be properly germinated leading to a very low plant stand in the field. This problem can be overcome by the application of some plant growth regulators. In an experiment, Khan (2013) reported that the percentage of corm germination varied significantly due to treatment of corms with GA_3 and BA. The maximum percentage of germination was 84.2% when the corms treated with 100 ppm GA_3

and 50 ppm BA and few numbers of plants (59.7%) were observed in the corms soaked with water. (Fig.1).

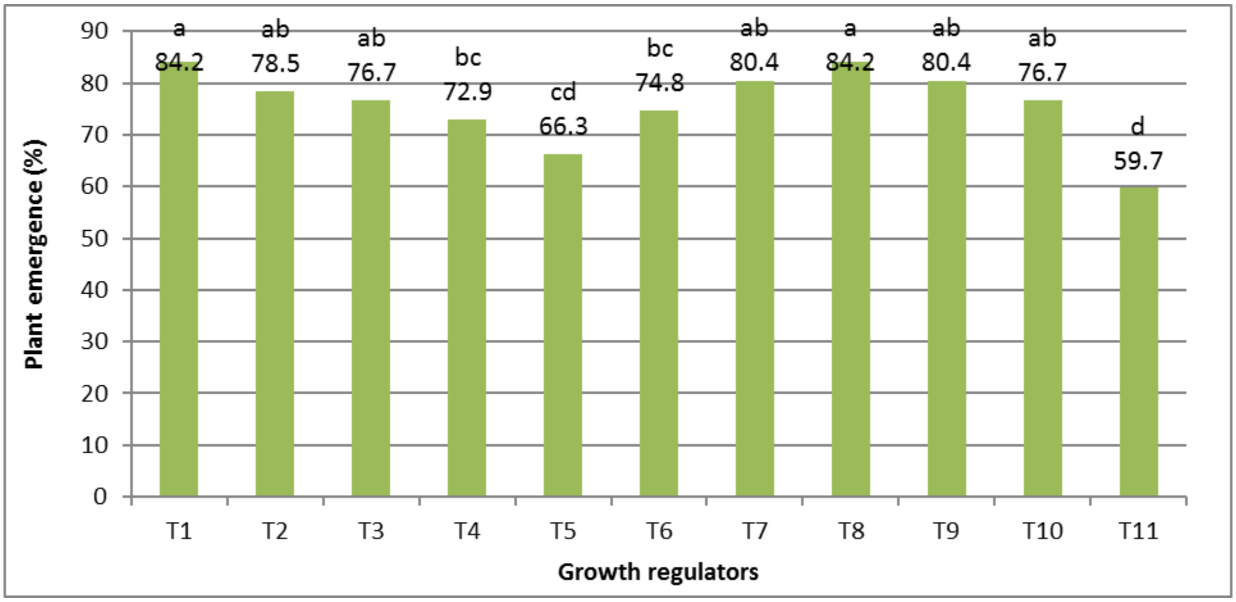

Fig. 1: Effect of BA and GA_3 on percentage of plant emergence in gladiolus.

Source: Khan, (2013)

T_1= BA 50 ppm	T_2= BA 75 ppm	T_3= BA 100 ppm	T_4= BA 125 ppm
T_5=BA 150 ppm	T_6= GA_3 50 ppm	T_7= GA_3 75 ppm	T_8=$GA_3$100 ppm
T_9= GA_3 125 ppm	T_{10}=GA_3 150 ppm	T_{11}= Control (Water soaked)	

In another experiment, Khan (2011) also showed that the days taken for germination were significantly influenced by the application of GA_3 and BA. GA_3 100 ppm took the minimum days (15 days) for 50% emergence compared control (23.67 days).

3.3.3 Growth Promotion

At presrnt plant growth regulators are also used to regulate the promotion of growth. GA_3 is the most popular growth promoting regulator which has extensive use in various flower crops. Apart from GA_3, there are some other plant regulators those are responsible for growth promotion. (Table4).

Table 4. Use of GA_3 in some important flower crops for growth promotion

Crops	Growth regulators	References
Chrysanthemum	GA_3	Bhattacharjee,1984
Dahlia	GA_3	Mittal,1967
Gladiolus	GA_3	Bhattacharjee,1984
Tuberose	GA_3	Mukhopadhyay & Banker,1983
Calendula	GA_3	Ram and Mehta, 1982

Vegetative growth : Vegetative growth of various cut flower and foliage plant are influenced by different plant growth regulators. plant height of tuberose also differed significantly due to the application of different concentration of growth regulators . At 50, 70, 90 and 110 days after planting, the tallest plant (21,6, 38.0, 53.9 and 63.0 cm) was recorded in bulb treated with GA_3 300 ppm followed by GA_3 200 ppm and GA_3 100 ppm. Whereas, the shortest plant was observed in treatment control for the same DAP (Fig:2). Application of GA_3 migth have resulated in cell division and cell elongation resulting in enhanced plan height. BA showed better performances compared to control.

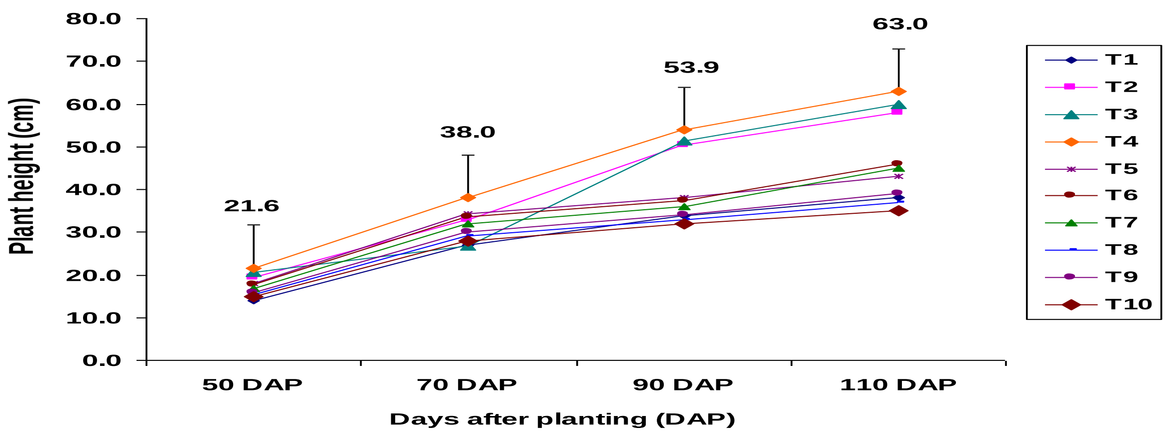

Fig.2. Effect of growth regulators on plant height of tuberose at different DAP .

Source : Sharifuzzaman *et al.*, (2016)

Here, T_1 : Control (Without growth regulators), T_2 : GA_3 100 ppm, T_3 : GA_3 200 ppm, T_4 : GA_3 300 ppm, T_5 : BA 100 ppm, T_6: BA 200 ppm, T_7 : BA 300 ppm, T_8 : CCC 250 ppm, T_9 : CCC 500 ppm and T_{10} : CCC 1000 ppm .

Different levels of growth regulators showed a significant variation for number of leaves/clump at flower harvesting stage. With the increases level of GA_3 100 ppm to 300 ppm number of leaves/clump represents an increasing trend (Talbe 5). On the other hand, the minimum number (42.0) of leaves/clump was recorded in control. These variations in number of leaves per clump might be due to that GA_3 improves the physiological efficiency of the plant such as improvement of rate of photosynthesis, control of transpiration and photorespiration, efficient water and nutrient uptake, control of leaf senescence thus inducing resistant to environmental stress and ultimately increasing the harvest index.

Table 5. Effect of growth regulators on vegetative growth of BARI Tuberose-1

Treatments	Leaves/clump	Plant spread (cm)	Plants/hill
T_1	42.0 e	13.5 c	4.0 c
T_2	57.0 b	20.0 ab	7.0 b
T_3	60.0 ab	20.5 ab	8.0 ab
T_4	62.5 a	22.0 a	8.5 ab
T_5	55.0 bc	19.0 ab	10.0 a
T_6	54.2 bc	18.6 ab	9.0 ab
T_7	52.0 c	17.5 b	7.5 ab
T_8	47.5 d	15.7 bc	7.0 b
T_9	50.0 cd	16.0 bc	6.0 bc
T_{10}	44.0 de	15.0 bc	5.5 bc
LSD (0.05)	1.6	2.0	1.8
CV (%)	9.9	11.6	10.5

Source: Sharifuzzaman *et al*., (2016)

T_1 : Control (Without growth regulators), T_2 : GA_3 100 ppm, T_3 : GA_3 200 ppm, T_4 : GA_3 300 ppm, T_5 : BA 100 ppm, T_6: BA 200 ppm, T_7 : BA 300 ppm, T_8 : CCC 250 ppm, T_9 : CCC 500 ppm and T_{10} : CCC 1000 ppm

The plant spread of tuberose plant is an important morphological character that influences the yield, because it is correlated with photosynthesis by the higher leaf area. The maximum plant spread (22.0cm) was recorded in GA_3 300ppm and the minimum plant spread (13.0cm) was observed in control. Similarly, the number of plants per hill was influenced by the application of different growth regulators. BA at 100ppm produced the highest number of plants per hill (10.0) followed by 200ppm (9.0 plant) while control produced the lowest number of plant (4.0). In another experiment, (khan, 2013) also found that BA enhanced multiple shooting compared to control (plate 1).

Plate 1. (a) Multiple shooting enhanced by BA 125 ppm treated corms compared to (b) single plant by water soaked corms (control).

Source : Khan ,(2013)

Flowering : Exogenous application of growth regulators can influenced flowering by retarding the vegetative growth (Table 6)

Table 6. Growth regulators in some important flower crops for flowering

Crops	Growth regulators	References
Rose	GA_3	Maharana and Pani, (1982)
Chrysanthemum	IAA, Ethrel,GA_3, TIBA	Manna & Mukherjee, (1983)
Dahlia	B-9, TIBA, MH	Bhattacharjee,(1984)
Tuberose	CCC, MH	Dhua *et al*.,(1986)
Gladiolus	NAA, Ethrel, GA_3	Ravidas *et al*., (1992)
Jasmin	GA_3 CCC	Gowda and Gowda (1991)
Marigold	GA_3	Singh *et al*.,(1991)
Lily	CCC, GA	Pal and Das, (1990)

In an experiment, Anonymous (2014) reported GA_3 elongated stems and increased the flower head size of cut roses (Plate 2).

Treated Untreated

Plate 2. Effect of GA_3 on stem length of rose flower .

Source : Anonymous, (2014)

The flowering parameters of chrysanthemum were significantly influenced by the application of GA_3. The treatment GA_3 150ppm took the minimum days to reach in bud initiation, bud initiation to fuul blooming (55.20 and 34.81 days respectively). Besides, water sprayed chrysanthemum plants took maximum days for the same parameter. The highest marketable branch (7.86), and total flowers/plant (60.73) were also demonstrated by 150 ppm GA_3 application. (Table 7).

Table 7. Application of GA_3 on flowering of chrysanthemum

Treatments (ppm)	Days taken to bud initiation	Days taken to bud initiation to full blooming	No. of marketable branch*	Flowers/Plant
50	58.53 b	36.35b	5.67c	38.70d
75	57.25 bc	36.01b	6.28bc	45.38c
100	55.49 c	35.68b	6.85b	52.80b
150	55.20 c	34.81c	7.86a	60.73a
0 (water)	61.94 a	37.39a	4.52d	24.48e
Level of Significance	**	**	**	**
C.V	**3.89**	**1.49**	**10.63**	**2.66**

Source: Khan *et al.*,(2016)

***Marketable branches were recorded on the basis of stalk length (>20cm) and number of flowers (>4)

In an experiment, khan, (2011) reported that remarkable amount of gladiolus flower sticks (spikes) were produced in first year with cormels and next year with the corms produced in the previous year influenced by BA and GA_3 with control.

T_1 T_2 T_3 T_4 T_5 T_6 T_7 T_8 T_9 T_{10} T_{11}

Plate 3. Production of flower sticks from corms produced in the previous year in fluenced by BA and GA3 with control .

Source: Khan,(2011)

T_1= BA 50 ppm, T_2=BA 75 ppm, T_3=BA 100 ppm, T_4=BA 125 ppm T_5=BA 150 ppm, T_6=GA_3 50 ppm, T_7=GA_3 75 ppm, T_8=GA_3 100 ppm T_9=GA_3 125 ppm, T_{10}=GA_3 150 ppm and T_{11}=control

GA_3 also can stimulates flowering in foliage plants. Flowering was occurred in *Syngonium sp* with a single foliar spray of GA_3 at 1000 mg L^{-1} (Plate 4)

Plate 4. A flowering plant of *Syngonium sp* with a single foliar spray of GA_3 at 1000 mg/L. Arrows indicate the flower .

Source: Henny and Norman,(1999)

Seed (corm, cormel, bulb and bulblet) production: Seeds like corm, cormel, bulb and bublets are also influenced by the application of various growth regulators. The highest percentage of corms (95.24%), the heaviest and the largest corm (19.74g and 3.85cm, respectively) the maximum number of corms ha^{-1}(117,000) were recorded by the treatment GA_3 100ppm through cormel planted $plot^{-1}$(Table).

Table 8. Effect of BA and GA_3 on corm production of gladiolus from cormel

Treatments (ppm)	Corms (%)	Corm weight (g)	Corm diameter (cm)	Corm yield ha^{-1} (000)
BA 75	73.02 de	17.43 abc	3.62 abc	90.0 c
BA 100	77.78 cd	16.36 abc	3.35 cd	96.0 bc
BA 125	87.3 abc	15.18 bc	3.32 d	108.0 ab
BA 150	72.22 de	14.35 c	3.18 d	89.0 cd
GA_3 75	88.89 abc	19.17 a	3.75 a	109.0 a
GA_3 100	95.24 a	19.74 a	3.85 a	117.0 a
GA_3 125	91.27 ab	17.25 abc	3.59 abc	112.0 a
GA_3 150	88.10 abc	16.18 abc	3.45 bcd	108.0 ab
Control	62.70 e	15.12 bc	3.25 d	77.0 d
Level of significance	**	**	**	**
CV (%)	5.13	8.63	3.14	5.07

Source: Khan,(2011)

Means with the same letter(s) are not significantly different at 1% level by DMRT

Rooting: Rooting play an important role in the propagation of difficult-to-root plant species. In recent year, difficult-to-root species are made to root by the use of growth regulators. Although many species of *Ixora* are relatively easy to propagate from cuttings, but sometimes slow rooting is a problem for certain species. Individual application of IBA and NAA improved the rooting percentage of Ixora cuttings compared to control but when they were used in combinations, showed better performance(Table 9).

Table 9. Rooting of *Ixora acuminata* cuttings as influenced by different root-promoting regulators (avg. of 100 cuttings/ treatment)

Treatment	Concentration (ppm)	Rooting (%)
Control	----	26 c
IBA	2500	43 b
	5000	49 b
NAA	2500	42 b
	5000	48 b
IBA & NAA	2500 & 2500	97 a
IBA & NAA	5000 & 5000	100 a

Source: Rauch and Yamakawa, (1980)

Mean separation in columns by Duncan's multiple range test, 5% level.

Majority of cultivars of Bougainvillea often fail to produce roots and hence results in poor survival of cuttings.

Table 10. Effect of growth regulators on rooting of Bougainvillea cv. Thimma cuttings

Growth regulators	Concentration (ppm)	% of rooting	Number of roots/cutting	Maximum root length (cm)
IBA	250	40.00	5.60	4.13
	500	46.67	7.47	7.20
	1000	73.33	12.00	9.73
NAA	250	26.67	4.27	3.20
	500	33.33	5.73	5.73
	1000	46.67	9.73	8.27
IAA	250	26.67	4.13	2.93
	500	40.00	6.67	6.63
	1000	46.67	9.73	8.00
control	0	26.67	4.53	4.47

Source: Panwar *et al.*, (1999)

From(Table 10) it is observed that percent rooting of cuttings, number of roots per cutting and root length increased significantly with varying concentrations. IBA at 1000 ppm was found most effective followed by IAA and NAA in all cases.

3.3.4 Growth retardation

The use of growth regulators to retard the stem elongation has been a very popular subject of research in ornamental crops. This is the area where lot of works has been carried out (Table 11). Growth retardants, which reduce plant height, are mostly synthetic compounds that either slow down cell division or inhibit cell elongation.

Table 11. Growth retardation regulators in some flowering and foliage plants

Crops	Growth regulators	References
Dahlia	Cycocel	Prasad and Kumar, 2003
Chrysanthemum	MH, Ethrel, CCC	Manna & Mukherjee, (1983)
Rose	CCC	Maharana & Pani,1982
Marigold	CCC, Ethrel, MH	Singh *et al*.(1991), Parmar & Singh (1983)
Carnation	MH	Dubey,1972
Jasmine	MH, CCC	Bhattacharjee, 1983
Hibiscus	CCC	Bhattacharjee *et al*., 1977
Coleus	A-Rest, Bonzi	Prasad and Kumar, 2003
Begonia	Cycocel	Prasad and Kumar, 2003

Plant growth retardants (PGRs) are commonly applied to container-grown plants to control stem elongation and produce high quality, compact plants. Topflor is a plant growth retardant, similar in its mode of action to A-Rest, Bonzi, and Sumagic, widely used in Europe. Topflor provide excellent growth control for various pot plants (Plate 5, 6 and 7).

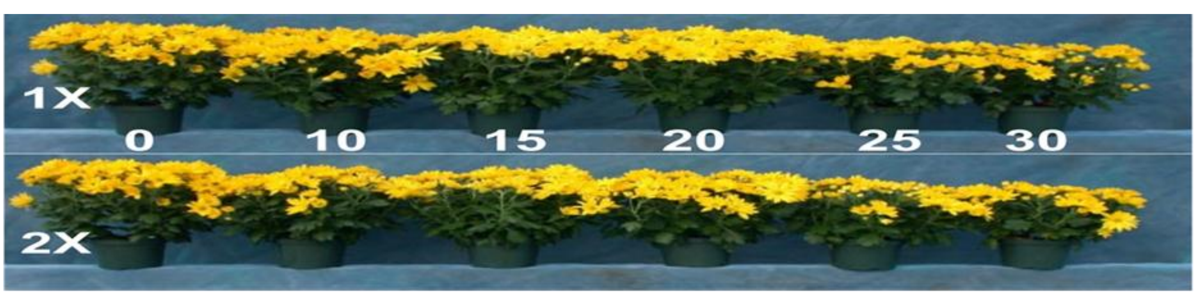

Plate 5.Topflor foliar sprays are effective in controlling the growth of "Yellow Blush" pot mum (top) sprayed once and (bottom) sprayed twice, with the second spray applied 2 weeks after the first. Rates are given in ppm

Plate 6. The response of poinsettias to Topflor foliar sprays. Rates are given in ppm

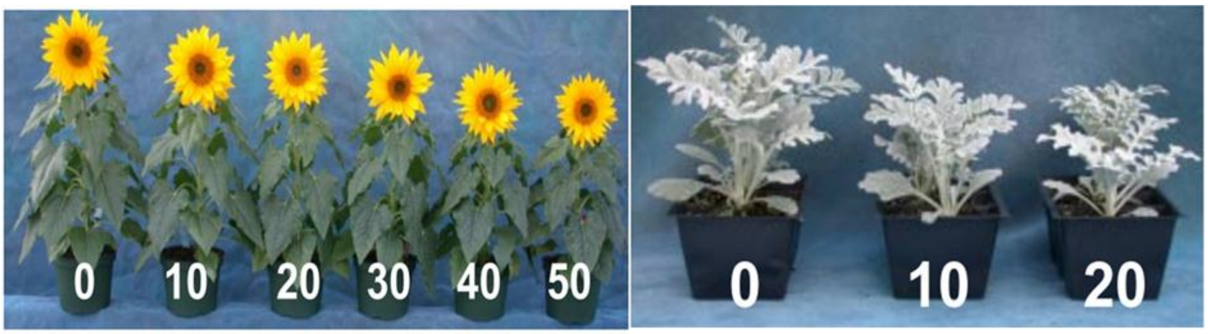

Plate 7. Topflor foliar sprays are effective in controlling the growth of pot sunflower and silver dust. Rates are given in ppm

Source: Whipker, (2001)

3.3.5. Senescence inhibition

Consumer acceptance of any flowering plant would increase if flower abscission is reduced. (Rao,1982) reported kinetin (10mg/l) was more effective in the delay of petal senescence in *Rosa damascena* than IAA and GA_3. 2% NAA has been reported to prevent senescence and dropping of petals in the flowers of *Ipomoea purpourea* (Parkhi and Khalatkar,1986).

(Behara *et al*.1990) found that the ABA treatment retarded petal senescence in leafy flowering shoots of cut carnation by reducing the loss of total protein.

Leaf yellowing, an early symptom of leaf senescence is an important factor in loss of quality of potted plants and cut flowers. But (Serek & Reid,1997) found that 6-benzyladenine (6-BA), a synthetic cytokinin, together with STS markedly improved plant quality.

3.3.6. Vase life

Prolonging the vase life of cut flowers is very important issue for helping the commercial growers as well as users. The growth regulators can be used with success not only for prolonging the life of cut flowers but also making possible to harvest blooms in tight bud stage and allowing them to open normally (Murti & Upreti, 1995).Some growth regulators, normally used in ornamental plants for prolonging vase life (Table 12).

Table 12. Growth hormones used in some cut flowers for prolonging vase life

Crops	Growth regulators	References
Chrysanthemum	SADH	Das & Barman,(1990)
Rose	Kinetin	Rao,(1982)
Gladiolus	BA, Thiourea	Rao *et al.*, (1983)
Tuberose	SADH	Das & Barman,(1990)
Carnation	Kinetin	Cook *et al.*, (1985)
Gerbera	CCC	Sharma *et al.*,(2002)

Ethylene can pose considerable problems in the post harvest handling of ornamentals, causing a range of effects, including early wilting of flowers, yellowing or necrosis (death) of leaves, and shattering of leaves, buds, petals and flowers. In recent years a number of growth regulator approaches to overcoming the effects of ethylene have become available. A new gaseous inhibitor of ethylene, 1-methylcyclopropene (1-MCP), is presently being registered for use with ornamentals and appears to have considerable commercial potential as an inhibitor of ethylene action(Serek & Reid,1997).

3.3.7. Plant tissue culture

In vitro clonal propagation through tissue culture is an effective method for large scale rapid multiplication of plants. Million of homogenous plants can be grown from a small plant tissue within a year. Plant growth regulators are widely used in plant tissue culture techniques. The four classes of growth regulators are commonly used in tissue culture media. The type of growth regulators and concentration used will vary according to the cell culture purpose.(Table 13).

Table 13. Growth regulators used and their functions in plant tissue culture

Growth regulators		Functions
Auxin	IAA ,NAA	It is required for the induction of cell division and root initiation in cultured tissues
	2,4-D ,IBA	
Cytokinins	Kinetin , 2ip	Promote cell division, shoot proliferaition, organogenesis and somatic embriogenesis
	BAP , Zeatin	
Gibberellins	GA_3	Used for plant regeneration and elongation
Abscisic acid	ABA	Useful in embryo culture somatic embryogenesis

Source: Prasad and Kumar, (2003)

The effect of BA and Kinetin on shoot proliferation and elongation in caladium bicolor was investigated by adding different concentrations of BA and Kinetin to a basal MS medium (semi-solid). In vitro culture of shoot tip results 16.67% shoot induction at 1.0mg/L BA whereas 13.33% shoot induction observed at 1.0mg/L kinetin. At control it was observed 3.33% shoot induction. Maximum number of shoot (5) initiated when MS media was supplemented with 1.0mg/L BA and minimum(1) was at control (Figure3).

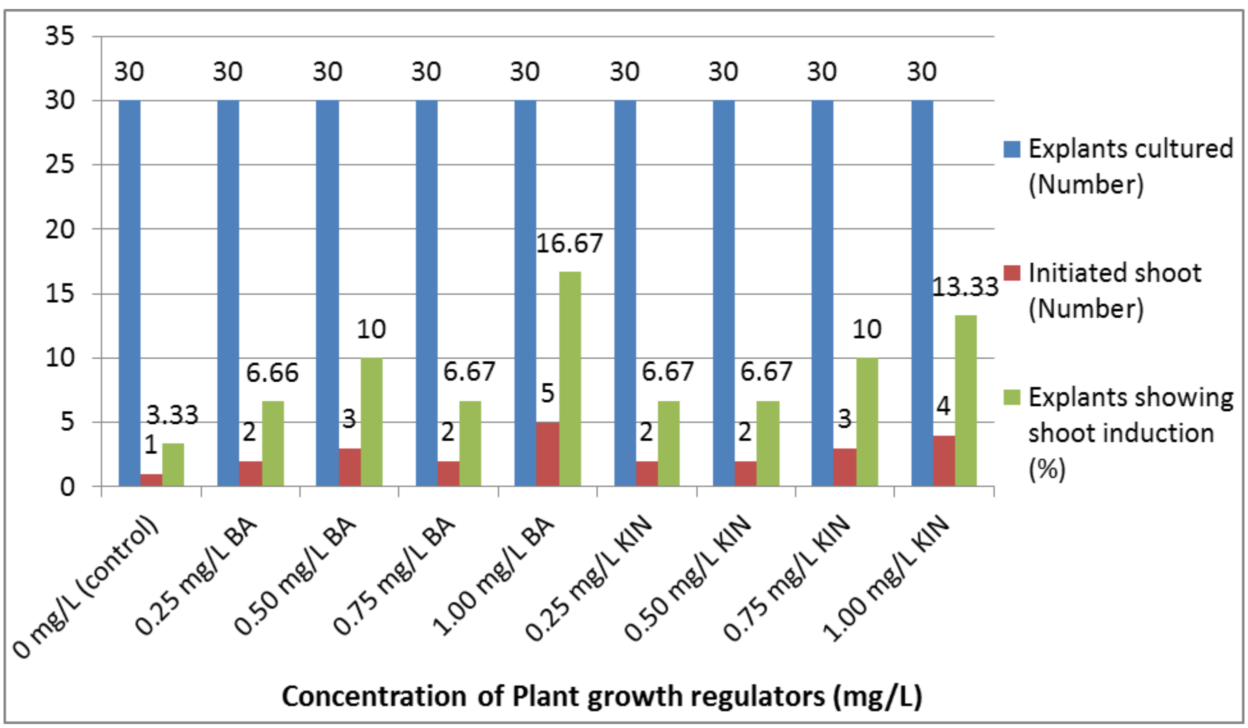

Figure 3. Effect of BA and Kin on shoot induction potentiality in *Caladium bicolor*.

Source : Ahmed , (2014)

Aglaonema—The use of GA_3 treatment is imperative for *Aglaonema* breeding to ensure simultaneous flowering of different species and cultivars. Natural flowering cycles of *Aglaonema* are highly variable and sporadic, which limits their ability to make cross pollinations. A single foliar spray with 250 ppm GA_3 consistently induces flowering and increases flower number in many *Aglaonema* species. Time from treatment to blooming is about 4–5 months (Henny 1983). *Aglaonema* flowers have no ornamental market value and are removed if not used for hybridization.

Dieffenbachia—The ability to flower *Dieffenbachia* species and cultivars simultaneously on demand has made breeding this popular plant much easier (Henny 1980). Flowering is accomplished by a single foliar spray with 250 ppm GA_3. Flowers normally mature within 3–4 months following treatment. Tetraploid *Dieffenbachia* breeding lines have proven more difficult to flower using GA_3 sprays and require higher treatment rates than diploid plants. Even at rates of 500 ppm, only 30%–80% of tetraploid *Dieffenbachia* flowered compared to 100% of diploids (Henny 1989).

Cordyline—Also known as Ti plant or Hawaiian good-luck plant, *Cordyline terminalis* produces terminal inflorescences 4–6 weeks after apical buds are treated with GA_3 or GA_{4+7} (Fisher 1980). Optimum flowering requires application of 0.12–0.15 ml of 500 ppm GA_3 or GA_{4+7} applied to the apical bud. Some selections of Ti plant are used extensively as cut florist greens. Flowers should be induced for breeding purposes only.

Misapplications and over dose can lead to catastrophic results, which lower plant quality. The symptoms of overdose and misapplication of plant growth regulators are shown in Plate 8 to 13.

Plate 8. Uneven application of plant growth hormones caused a reduction in the size of poinsettia bracts.

Plate 9. A more severe case of leaf yellowing due to cycocel phytotoxicity of poinsettia.

Plate 10. Leaves which are darker green and crinkled are typical overdose symptoms .

Plate 11. Pancy plant received an over application of cycocel (4,000ppm) resulting in marginal leaf necrosis .

Plate 12. Excessive rates of Bonzi necrosis and stunted growth of dahlia .

Plate 13. A close up of geranium flowers showing the abortion caused by florel .

Source : Whipker, (2004)

CHAPTER IV

4.0. CONCLUSION

1. The possible areas are breaking of dormancy, better seed germination, growth promotion and retardation, flowering, rooting, prolonging plant and flower life in where exogenous application of plant growth regulators can be done .

2. Application of BA, Ethrel, and GA_3 are mainly responsible to break dormancy in several cut flowers and foliage plants and GA_3 showed very good response regarding seed germination, growth promotion and senescence inhibition.

3. Auxins like IBA, IAA and NAA were found as effective root promoting growth regulators but combination of these growth regulators showed better performances. Moreover, auxins and cytokinins were essential for in vitro clonal propagation through tissue culture.

4. Ethrel, cycocel, B-Nine, SADH, Bonzi, A-rest, Topflor strongly retard the plant height and stimulated branching, increased number, size and yield of flowers.

5. Kinetin, NAA, ABA, 6-BA, Cycocel were also found effective to dealy senescence and there by prolong vase life of cut flowers.

REFERENCES

Ahmed,S.K.(2014). In vitro regeneration of *Caladium bicolor,* MS Thesis, Department of biotechnology, Sher-e-bangla Agricultural University, Dhaka -1207.

Anonymous, (2014). Plant regulating rose stems. *Israeli agriculture International portal*.

Behera, P. K., Sarangi, C. S., Mishra, D., & Patra, H. K. (1990). Effect of abscisic acid and kinetin on enzyme activities during petal senescence in cut carnation flowers. *Israel journal of botany*, *39*(3), 229-238.

Bhattacharjee, S. K. (1983). Growth and flowering of Jasminum grandiflorum L. as influenced by growth regulating chemicals [in India]. *Singapore Journal of Primary Industries*.

Bhattacharjee, S. K. (1984). The Effects of Growth Regulating Chemicals on Gladiolus/Die Wirkung von Wachstumsregulatoren auf Gladiolus. *Gartenbauwissenschaft*, 103-106.

Bhattacharjee, S. K. (1984). Effect of growth regulating chemicals on growth and flowering and tuberous root formation of dahlia variablis. *Punjab Horticultural Journal*, *24*(1/4), 138-144.

Bhattacharjee, S. K., Mukherjee, T. P., & Bose, T. K. (1977). Dwarfing of Hibiscus rosa sinensis L. using CCC as a soil drencn. *Punjab horticultural journal*,17:164-167.

Campo, J.B.(2001). Export potentialities of ornamental plants from Bangladesh. In: Development of Chinese palm and other ornamental plants. Hortex foundation, Sher-e-Bangla Nagar, Dhaka

Chopra, V.L.(1994). Indian Floriculture: An Overview. In: Floriculture, Technology, Trades & Trends. Edited by Prakash and Bhandary. Oxford & IBH Publishing Co. Pvt. Ltd. Calcutta. pp. 3-9.

Cook, D., Rasche, M., & Eisinger, W. (1985). Regulation of ethylene biosynthesis and action in cut carnation flower senescence by cytokinins. *Journal of the American Society for Horticultural Science (USA)*.110 (1):24-27 .

Dadlani, N. K. (2003). Global positioning of Bangladesh floriculture. In *A Paper presented on a Seminar held on 6th November*.

Das, S. N., & Barman, D. (1990). Effect of some chemicals on vase life of cut tuberose. *Punjab Horticultural Journal*, *30*(1-4), 203-205.

Dhua, R. S., Ghosh, S. K., Mitra, S. K., Yadav, L. P., & Bose, T. K. (1986). Effect of bulb size, temperature treatment of bulbs and chemicals on growth and flower production in tuberose

(Polianthes tuberosa L.). In *Symposium on the Development of New Floricultural Crops, XXII IHC 205* (pp. 121-128).

Dubey, K.C.(1972). Effect of Mallic Hydrazide on the Vegetative Growth and Flower Production in Carnation (*Dianthus caryophyllus* L.). Plant Science, 4: 121-123.

Fishel, F. M. (2007). Plant Growth Regulators. University of Florida. IFAS Extension. PI-102.

Fisher, J. B. (1980). Gibberellin-induced flowering in Cordyline (Agavaceae). *Journal of Experimental Botany*, *31*(3), 731-735.

Gauchan, D. P., Pokhrel, A. R., Pratap, M., & Lama, P. (2009). Current status of cut flower business in Nepal. *Kathmandu University Journal of Science, Engineering and Technology*, *5*(1), 87-98.

Gowda, V.N. and Gowda, J.V.N.(1991). Regulation of Flowering of Gundumallige by Gibberellic Acid Spray. Current Research USA, 20:11-12.

Henny, R. J., Norman, D. J., & Kane, M. E. (1999). Gibberellic Acid-induced Flowering of Syngonium podophyllum SchottWhite Butterfly'. *HortScience*, *34*(4), 676-677.

Henny, R. J. (1980). "Gibberellic Acid (GA_3) Induces Flowering in *Dieffenbachia maculata* 'Perfection'." *HortScience* 15 (5): 613.

Henny, R. J. (1983). Flowering of Aglaonema commutatum'Treubii'following treatment with gibberellic acid. *HortScience*.

Henny, R. J. (1989). Floral induction in 2n and 4n Dieffenbachia maculata perfection after treatment with gibberellic acid. *Horticulture Science*, *24*(2), 307-308.

Islam, M. (2013). Godkhali-te Pacth Koti Takar Ful Bikri (Bangla). 15th February, Prothom-alo.

Khan, F. N. (2009). Techniques of corm and cormel production in gladiolus. *A Ph. D dissertation submitted to Dept. of Horticulture, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Salna, Gazipur*, 1-3.

Khan, F. N., Rahman, M. M., Hossain, M. M., & Hossain, T. (2011). Effect of benzyl adenine and gibberellic acid on dormancy breaking and growth in gladiolus cormels. *Thai Journal of Agricultural Science*, *44*(3), 165-174.

Khan, F. N., Rahman, M. M., Hossain, M. M., & Gazipur, B. (2013). Effect of benzyladenine and gibberellic acid on dormancy breaking, growth and yield of gladiolus corms over different storage periods. *Journal of Ornamental Plants*, *3*(1), 59-71.

Khan,F.N., Naznin,A. Bhuyian,M. R.Rashid, M.T. and Ara,K. A.,(2016). Foliar application of GA_3 on growth and flowering of standard chrysanthemum, Annual research report 2015-2016,Bangladesh Agricultural Research Institute, pp 64-69 .

Maharana, T., & Pani, A. (1982). Effect of Post pruning spraying of different growth regulators on the growth and flowering of a hybrid rose. *Bangladesh Horticulture, 10*(1), 1-4.

Manna, D. C., & Mukherjee, D. (1983). Effects of ethrel on growth and flowering of chrysanthemum (*Chrysanthemum morifolium* Ram.). *Indian Agriculturist*.

Mittal, S. P. (1967). Studies on the effect of gibberellins on growth and flowering of dahlia. *Madras Agricultural Journal*, *54*, 103-107.

Mukhopadhyay, A., & Bankar, G. J. (1983). Regulation of growth and flowering in Polianthes tuberosa L. with gibberellic acid and ethrel spray. *Scientia Horticulturae*, *19*(1-2), 149-152.

Murti, G.S.R. and Upreti, K.K.(1995). Use of Growth Regulators in Ornamental Plants. In: Advances in Horticulture. Vol.12-Ornamental plants. Eds: K.L. Chada and S.K. Bhattacharjee. Malhotra Publishing House, New Delhi, India. pp. 863-883.

Narayana, and Gowda,J.V.(1994). Effect of Ethrel and Benzyladenine on Breaking Dormancy in Gladiolus Cormels. Floriculture Technology, Trades and Trends. Edited by Prakash and Bhandary. Oxford & IBH Publishing Co. Pvt. Ltd. Calcutta. pp. 203-204.

Pal, A. K., & Das, S. N. (1990). Effect of growth regulators on growth and flowering of Lilium longiflorum. *Orissa Journal of Horticulture*, *18*(1-2), 18-21.

Panwar, R. D., Gupta, A. K., Yamdagni, R., & Saini, R. S. (1999). Effect of growth regulators on the rooting of cuttings of bougainvillea Cv. Thimma. *Haryana Agricultural University Journal of research*, *29*(1-2), 11-17.

Parkhi, R.D. and Khalatkar, A.S.(1986). Incompatibility in *Ipomoea purpurea* (Roth). Plant Incompatibility Newsletter, 18:13-18.

Parmar, A.S. and Singh, S.N.(1983). Effect of Plant Growth Regulators in Growth and Flowering of Marigold (*Tagetes erecta*). *South Indian Horticulture*, 31:53-54.

Prasad, S. and Kumar U. (2003). Bedding Plants Production for Floriculture. In: Commercial Floriculture. Published by Agrobios (India). pp. 244-279.

Prasad, S. and Kumar U.(2003). Techniques of Plant Tissue Culture for Flower Production. In: Commercial Floriculture. Published by Agrobios (India). pp. 280-383.

Ram, H. M., & Mehta, U. (1978). Effect of gibberellic acid on the growth of main shoot and axillary branches inCalendula officinalis. *In Proceedings of the Indian Academy of Sciences-Section B*, 87(11), 255-270).

Randhawa, G.S.(1971). Plant Growth Regulators and GA. Indian Council of Agric. Research., Newdelhi. pp. 139.

Rao, G. N. (1982). Delaying of Rosa damascena petal senescence by certain plant growth regulators. *Current Science*.

Rao. T.R., G.S.R. Murti and P. Challa. 1983. Cytokinins in Gladiolus (*Gladiolus grandiflorus*) Corm. *Annals Botanny*, 52: 703-710.

Rauch, F. D., & Yamakawa, R. M. (1980). Effects of auxin on rooting of *Ixora acuminata*. *Horticulture Science*, *15*(1).

Ravidas, L.,Rajeevan, P.K. and Valsalakumari P.K.(1992). Effect of Foliar Application of Growth Regulators on Growth, Flowering and Corm Yield of Gladiolus cv. 'Friendship'. *South Indian Horticulture*, 40:329-335.

Serek, M., & Reid, M. S. (1997). Use of growth regulators for improving the postharvest quality of ornamentals. *Perishables Handling Quarterly*, *92*, 7-9.

Sharifuzzaman, Ara,N. and Naznin,A.(2016). Influence of growth regulators on growth, Flowering and bulb production of tuberose. Annual research report 2015-2016,Bangladesh Agricultural Research Institute, pp. 72-79.

Nair, S. A., Singh, V., & Sharma, T. V. R. S. (2002). Effect of plant growth regulators on yield and quality of gerbera under Bay Island conditions. *Indian Journal of Horticulture*, *59*(1), 100-105.

Singh, M. P., Singh, R. P., & Singh, G. N. (1991). Effect of GA 3 and ethrel on the growth and flowering of African marigold (Tagetes erecta L.). *Journal of Horticulture. Science*, *2*, 81-84.

Whipker, B.E.(2004)**.** Topflor: A New Plant Growth Regulator. Horticulture Research Series No.156. North Carolina State University,Raleigh, NC 27695-7609. pp. 1-4.