Effect of different concentrations of GA_3, NAA and MH on vegetative, floral and yield attributes of China aster [*Callistephus chinensis* (L.) Nees] cv. Poornima.

Thesis

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By

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अपर्णा

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CERTIFICATE

This is to certify that the thesis entitled **"Effect of different concentrations of GA_3, NAA and MH on vegetative, floral and yield attributes of China aster [*Callistephus chinensis* (L.) Nees] cv. Poornima"** submitted in partial fulfillment of the requirements for the degree of **Master of Science (Horticulture)** with major in **Floriculture and Landscape Architecture** of the College of Horticulture, VCSG Uttarakhand University of Horticulture & Forestry, Bharsar, is a record *of bona fide* research carried out by **Miss Aparna Rawat, I.D. No. 15231**, under my supervision and no part of the thesis has been submitted for any other degree or diploma.

Prof. B. P. Nautiyal
Chairman
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CERTIFICATE

We, the undersigned, members of the Advisory Committee of **Miss Aparna Rawat, I.D. No. 15231**, a candidate for the degree of **Master of Science (Horticulture)** with major in **Floriculture and Landscape Architecture** agree that the thesis entitled **"Effect of different concentrations of GA_3, NAA and MH on vegetative, floral and yield attributes of China aster [*Callistephus chinensis* (L.) Nees] cv. Poornima"** may be submitted in partial fulfilment of the requirements for the degree.

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CONTENT

LIST OF TABLES

LIST OF FLGURE

LIST OF PLATES

LIST OF APPENDICES

LIST OF SYMBOLS AND ABBREVIATIONS

%	:	Per cent
@	:	At the rate of
°C	:	Degree centigrade
A.D.	:	Anno Domimi (years after the traditional date of christ's birth)
ANOVA	:	Analysis of Variance
CCC	:	Cycocel
CD	:	Critical difference
cm	:	Centimeter
cm^2	:	Square centimeter
cv.	:	Cultivar
DAT	:	Days after transplanting
et al.	:	And others
E-W	:	East –West
g	:	Gram
GA_3	:	Gibberellic Acid
ha	:	hectare
i.e.	:	That is
IARI	:	Indian Agricultural Research Institute
IIHR	:	Indian Institute of Horticultural Research
K	:	Potassium
Kg	:	Kilogram
L	:	Litre
m^2	:	Square meter
mg	:	Milligram
MH	:	Maleic Hydrazide
mL	:	Millilitre
N	:	Nitrogen
NAA	:	Naphthalene Acetic Acid
N-S	:	North-South
OUAT	:	Orissa University of Agriculture and Technology
P	:	Phosphorus

PGR	:	Plant growth regulators
ppm	:	Parts per million
q	:	Quintal
RCBD	:	Randomized Complete Block Design
SEd	:	Standard error of deviation
SEm	:	Standard error of treatment mean
t	:	Tonnes
USSR	:	Union of Soviet Socialist Republics (Russia)
Viz.	:	Namely
Zn	:	Zinc

INTRODUCTION

CHAPTER 1

INTRODUCTION

China aster [*Callistephus chinensis* (L.) Nees] belongs to one of the largest family of flowering plants, 'Asteraceae'. It is native to China and has spread to Europe and other tropical countries during 1731 A.D. It is also an important flower crop of Siberia, USSR, Japan, North America, Switzerland and Europe. The present day asters have been developed from a single form of wild species, *Callistephus chinensis.* It was first named by Linnaeus as *Aster chinensis* and Nees subsequently changed this name to *Callistephus chinensis.* The name of the genus *Callistephus* is derived from two Greek words *kalistos* meaning most beautiful and s*tephos* means a crown, referring to the flower head (Janakiram, 2006). The aster bloom contains two kinds of florets: ray florets and disc florets. The bloom type depends mainly upon the relative number of the two kinds of florets and their shapes. The most suitable character for the classification of China aster is by shape of the ray florets. The present day varieties are available in diverse forms, types and a wide spectrum of colour ranges like pink, primrose, pale blue, mauve, purple, scarlet, creamy white, pure white and violet. (Dua and Pal, 2003)

It is a free blooming, half hardy and winter annual generally grown for cut as well as for loose flower purpose. It can be grown in various agro climatic zones. Both marginal and small farmers in various parts of our country are largely cultivating it as traditional crop. Its cultivation is becoming popular around the cities for its extensive use as cut flower in making bouquets, buttonholes and garlands. In ornamental gardening, it finds use as a bedding plant, edging, pot plant and herbaceous border. Dwarf types are highly suitable for edging and window boxes. Loose flowers are used in garland making. It is also a popular pot plant. It is also found suitable for inter-cropping in coconut gardens.

The growing popularity of China aster in most of the major cities in India has led to its cultivation as annual commercial crop for cut flower. In India, it is being grown on a large scale in Karnataka, Tamil Nadu, Andhra Pradesh, Maharashtra and West Bengal. In importance it ranks next to chrysanthemum and marigold among the traditional annual flowers. Increase in flower production both qualitatively and quantitatively and reduction in the plant form are the important objectives to be reckoned in commercial flower cultivation.

Among the various factors, which contributes to the growth, yield and flower quality, plant bio-regulators are important aspect of crop production. Application of plant growth regulators have been an essential part of floriculture and utilization of growth substances constituted one of the most important advances in agro-technology for improving the yield and quality parameters of flowers. They have been used in floriculture to manipulate plant growth in a desired direction (Sharma *et al.,* 2001). They are the organic chemical compounds which modify or regulate physiological processes in plants. They are readily absorbed and move rapidly through tissues when applied to different parts of the plant. They enhance the rapid changes in physiological and biochemical characters and improve crop productivity. They are applied in small quantity to promote or inhibit or quantitatively modifies growth and development of plants.

The exogenous application of growth regulators stimulate flowering, pollination, fertilization and seed setting to yield better quality seeds (Sunitha, 2007). The growth retardants helps in producing dwarf plants with compact shape flowers as well improving the flower longevity (Munikrishnappa and Chandrashekar, 2014). Various studies have shown that plant processes including senescence, are controlled through a balance between plant hormones interacting with each other and with other internal factors. Application of plant growth regulators is playing a leading role in production and post harvest handling of cut flowers. The pre-harvest application of plant growth regulators and chemicals plays a key role in controlling growth, promotion of flowering, prolonging the vase life of flowers by retarding senescence in many ornamental crops.

The growth regulators are classified in various groups *viz.*, auxins, gibberellins, cytokinins, inhibitors and retardants etc. Their effect varies with plant, species, variety, their concentrations used, method of application, frequency of applications and various factors which influence the absorption and translocation of the chemicals. The most widely available plant growth regulators are GA_3 and NAA which increase the plant growth by enhancing the cell division and cell elongation in meristematic tissues. GA_3 is commonly known as gibberellic acid. It is a plant hormone which is present in variety of organs and tissues like roots, shoots, buds, leaves, floral apices, root nodules, fruits and callus tissues. This promotes stem elongation and germination of dormant seeds or buds. It retards the initiation of floral senescence and maintains the quality of the flowers. It can substitute for long day requirement and can also overcome the need for an inductive cold period (Salisbury and Ross, 2004). Gautam *et al.* (2006) reported that Gibberellic acid increased to be very effective in manipulating growth and flowering in chrysanthemum. Naphthalene Acetic Acid is a synthetic auxin and it act as a root growth promoter which improves plant growth (Ullah *et al.,* 2013). It also causes cell division, cell enlargement in apical region and inhibition of lateral buds (Noggle and Fritz, 2010).

Plant growth retardants generally have the greatest effect on expanding or elongating cells, where inhibition of GA synthesis rapidly causes reduction in stem elongation and leaf expansion (Leclerc *et al.,* 2006). Maleic Hydrazide is a growth retardant which slows down the cell division and cell elongation. These chemical substances regulate the plant height and other growth aspects without formative effects and change in morphology and physiology of the plant. It was found to inhibit completely the formation of flower primordia in Wintex barley (Klein and Leopold, 1951).

Keeping the above points in view, a comprehensive study was conducted to assess the effect of foliar spray of different concentrations of GA_3, NAA, and MH on vegetative, floral and yield attributes of China aster [*Callistephus chinensis* (L.) Nees] cv. Poornima with following objectives:

- To study the effect of different concentrations of growth regulators GA_3, NAA and MH on vegetative and floral parameters.
- To study the effect of different concentrations of growth regulators GA_3, NAA and MH on seed yield.

REVIEW OF LITERATURE

CHAPTER 2

REVIEW OF LITERATURE

China aster is one of the commercially important cut as well as loose flower crop ranking next to chrysanthemum and marigold. Its cultivation is highly remunerative and has good export potential. In recent past, the use of synthetic plant growth regulating chemicals has gained momentum as a practical tool for crop growth regulation, particularly for cut flower and loose flower production. Hormone application has been an essential part of floriculture. Within the broad group of plant hormones, some act as growth promoters, while others act as growth retardants. Growth promoters as well as growth retardants have been commercially used in floriculture to manipulate plant growth in a desired way. Plant growth regulators have played a significant role by modifying root and shoot growth. Generally their site of action and biosynthesis are different. Most of the plant growth regulators exhibit a broad spectrum and thus a single PGR may influence several entirely different processes.

The component of present investigation concerning the effect of GA_3, NAA and MH on vegetative, floral and yield parameters for flower crops has been studied by various workers. It will be useful to review these works in China aster as well as related flower crops and supplement the view to strengthen the concept developed from present study. Thus after screening wide spectrum of literature available on this topic, some of the most relevant one are being presented for vegetative and floral attributes and seed yield under the following heads:

2.1 Effect of different concentrations of Gibberellic acid on vegetative parameters

Girwani *et al*. (1990) studied the effect of different concentrations of GA_3, CCC and Zn sprays in African marigold cv. African Giant. They reported that application of GA_3 @ 100 ppm was found more effective in inducing maximum plant height (122.77 cm) along with lesser number of branches per plant (59.18).

Dahale *et al*. (1994) conducted an experiment with four sprays of GA_3 comprising 3 levels at an interval of 15 days from third month of planting on 12 varieties of chrysanthemum. They reported that GA_3 @ 100 ppm on variety Gomati recorded maximum plant height (88.5 cm) and number of branches (29.00).

The effect of plant growth regulators on growth and yield of China aster cv. Kamini was studied by Ramesh *et al*. (2001). They reported that GA_3 @ 150 ppm applied at 60 days after planting produced maximum plant height (75.10 cm). They also found that different concentrations of GA_3 i.e., 100, 150 & 200 ppm exhibited less number of branches than other applied growth substances.

Sharma *et al*. (2001) assessed the effect of GA_3 on four cultivars of *Chrysanthemum morifolium.* The results showed that spray of GA_3 increased number of branches in all the cultivars. They further reported that effect was more pronounced in dwarf varieties and maximum number of branches was observed with GA_3 @ 50 ppm (13.50) in cv. Premier.

Padaganur *et al.* (2005) studied the effect of growth regulators on vegetative attributes of tuberose cv. Single. They observed that maximum plant height (31.52 cm), number of leaves (40.68), number of shoots (8.67) and leaf area (2009.06 cm^2) were produced in the plants sprayed with GA_3 @ 150 ppm.

Gautam *et al*. (2006) observed the effect of GA_3 on growth and flowering of *Chrysanthemum morifolium* cv. Nilima. Study revealed that GA_3 at all levels promoted the growth. The application of GA_3 @ 200 ppm produced maximum plant height (72.24 cm) and number of branches (23.67) over control.

Sunitha (2007) studied the effect of growth regulators on plant growth, seed yield and quality of African marigold (*Tagetes erecta* Linn.) and recorded that maximum plant height (101.2 cm) was observed in plants of African marigold which were sprayed with GA_3 @ 200 ppm as compared to other treatments applied.

Swaroop *et al*. (2007) assessed the influence of different plant growth regulators on growth of African marigold cv. Pusa Narangi Gainda. They reported that foliar spray of GA_3 @ 300 ppm recorded maximum plant height (89.50 cm) and number of primary branches per plant (8.75) compared to other treatments applied.

Umrao *et al*. (2007) noticed that application of GA_3 @ 300 ppm recorded maximum plant height (97.17 cm) in gladiolus.

Rajani (2008) carried out a field trial during *Kharif* season of 2007 to study the effect of certain growth regulators on growth and flower yield of tuberose (*Polianthes tuberosa* L.) cv. Single. The treatments consisted of three growth regulators at different concentrations *viz*., GA_3 (100, 150 and 200 ppm), CCC (500, 1000 and 1500 ppm) and MH (500, 1000 and 1500 ppm). Among all the treatments GA_3 @ 200 ppm recorded highest values in respect of growth parameters viz., plant height (43.24 cm), number of leaves (20.07), and leaf length (54.43 cm).

Nandre *et al*. (2009) conducted an experiment to study the effect of plant growth regulators on growth, flowering and yield of China aster cv. Poornima. The result revealed that GA_3 @ 200 ppm exhibited significant effect on plant growth and recorded maximum plant height (50.43 cm).

Kumar *et al.* (2012) studied the influence of various growth regulating chemicals on growth, yield and quality characters of cut rose cv. First Red. The study involved pre harvest spraying with gibberellic acid (5 and 100 ppm), maleic hydrazide (50 and 100 ppm) and salicylic acid (25 and 50 ppm). Gibberellic acid at higher concentration of 100 ppm as a pre harvest spray exerted a significant influence on crop growth and recorded maximum plant height (76.18 cm), stem girth (1.66 cm) and total chlorophyll content (1.826 mg / g).

Sainath *et al.* (2014) reported that *Chrysanthemum coronarium* L plants sprayed with GA_3 @ 200 ppm recorded maximum plant height (97.28 cm)

Kumar *et al.* (2015) conducted a field experiment on effect of plant bio-regulatores on growth, flowering and seed yield in China aster (*Callistephus chinensis* (L.) Nees) cv. Kamini. They reported that maximum plant height (36.38 cm), number of primary branches and secondary branches per plant (24.60 and 61.45, respectively) at 90 days after transplanting was recorded from the plants sprayed with gibbrellic acid @ 200 mg/L.

Sethy *et al.* (2016) studied the effect of three plant growth regulators on ornamental sunflower each at three concentrations viz., GA_3 (50,100, 200 ppm), Ethrel (250, 500, 750 ppm) and MH (500, 1000, 1500 ppm). The experiment was carried out in the Department of Floriculture and Landscaping, OUAT, Bhubaneswar and the growth regulators were applied in form of foliar spray, once at 30 days after seed sowing and again after 15 days of first application. The results of the study revealed that application of GA_3 @ 200 ppm recorded significantly increased plant height (139.55 cm), spread in East-West (59.42 cm) and North-

South direction (61.47 cm) and number of leaves per plant (26.66) at 75 days after sowing as compared to control.

2.2 Effect of different concentrations of Gibberellic acid on floral and seed yield parameters

Kore *et al*. (2003) investigated the effect of different levels of GA_3 on flower quality and yield of China aster cv. Ostrich Plume Mixed. They reported that foliar spray of GA_3 @ 200 ppm recorded highest flower yield (89.44 q per ha).

Padma and Chezhiyan (2003) studied the effect of GA_3 on four cultivars of Chrysanthemum (*Dendranthema grandiflora* Tzelvev). They found that application of GA_3 significantly advanced the flowering from bud initiation (57.63 days) as compared to other treatments applied.

Gautam *et al*. (2006) reported that application of GA_3 @ 200 ppm recorded the maximum flowers weight per plant (128.11 g) and flower yield (14.23 tons per ha) in *Chrysanthemum morifolium* cv. Nilima.

Swaroop *et al*. (2007) conducted a field experiment to study the effect of GA_3 on vegetative growth, flower characters of African marigold cv. Pusa Narangi Gainda during mild off seasons. They reported that application of GA_3 @ 300 ppm recorded maximum fresh weight of single flower (6.92 g), flower yield per plant (433.00 g) and number of flowers per plant (23.75).

Sunitha (2007) studied the effect of growth regulators on plant growth, seed yield and quality of African marigold (*Tagetes erecta* Linn.) and found that application of GA_3 @ 200 ppm recorded maximum number of flowers per plant (68.7).

Nandre *et al*. (2009) conducted an experiment to study the effect of plant growth regulators on growth, flowering and yield of China aster cv. Poornima. They reported that numbers of flowers per plant (68.54) were found maximum in those plants which were treated with GA_3 @ 200 ppm. While an early flowering (54.33 days) was noticed from the plants treated with GA_3 @ 100 ppm.

Patel *et al*. (2010) reported that application of GA_3 @ 150 ppm recorded significantly minimum days for first flower initiation (108.33 days) and maximum flower diameter (8.76

cm), flower weight (5.93 g), flower yield per plant (170.77 g) and shelf life of flowers (8.00 days) over control in *Chrysanthemum morifolium* Ramat cv. IIHR-6.

Kumar *et al.* (2012) conducted a study to assess the influence of various growth regulating chemicals on growth, yield and quality characters of cut rose cv. First Red. They gibberellic acid as a pre harvest spray at a higher concentration of 100 ppm exerted a significant influence on crop growth and recorded maximum stalk length (60.98 cm).

Chauhan *et al.* (2014) studied the effect of gibberellic acid on flowering and cut flower yield in gerbera cv. Alcochete under protected condition using various gibberellic acid levels viz., GA_3 @ 50, 100 and 150 ppm. The results revealed that application of GA_3 @ 100 ppm performed better for flower stalk length and thickness (54.32 cm and 6.20 cm, respectively).

The effect of different plant growth regulators on floral and yield attributing characters of China aster was studied by Munikrishnappa and Chandrashekhar (2014). Among the different treatments of GA_3, NAA, CCC, MH and Paclobutrazol applied, spraying of GA_3 @ 200 ppm enhanced the duration of flowering (90.33 days), number of flowers per plant (68.54), flower diameter (4.86 cm), flower weight (3.26 g) and vase life (22.88 days).

Sainath *et al.* (2014) found that spraying of GA_3 @ 200 ppm recorded significant increase in number of capitulum per plant (91.60), capitulum diameter (6.15 cm), number of seeds per capitulum, dry weight of capitulum (0.747 g), 1000 seed weight (2.14 g), seed yield per plant and per hectare (6.75g and 500 kg, respectively) as compared to control in annual chrysanthemum (*Chrysanthemum coronarium*).

Chopde *et al.* (2015) conducted a study on growth, yield and quality parameters of gladiolus as influenced by growth regulators during *rabi* season. The results revealed that spike length (94.19 cm), spike longevity (13.53 days) and number of spikes per plant (2.88) were found maximum from the plants treated with GA_3 @ 200 ppm.

Kumar *et al.* (2015) found that application of GA_3 @ 200 mg/L recorded maximum number of flowers per plant (84.96), seed yield per plant (9.98 g), seed yield per ha (1509.31 kg) and 1000 seed weight (2.01 g) in China aster (*Callistephus chinensis* L. Nees) cv. Kamini.

Patil *et al.* (2016) assessed the response of plant growth regulators on seed yielding attributes of African marigold. They reported that maximum seed yield per plot (994.72 g) and weight of seeds per flower (1.21 g) were recorded with the foliar treatment of GA_3 @ 300 ppm.

2.3 Effect of different concentrations of Naphthalene Acetic Acid on vegetative parameters

Singh and Rathore (1992) studied the effect of different concentration of NAA on vegetative attributes of African marigold. They reported that plants sprayed with NAA @ 25 ppm recorded maximum plant height (161.07 cm) and number of primary branches per plant (17.26) in African marigold as compared to plants sprayed with NAA @ 50 ppm (148.40 cm and 15.50, respectively).

Sooch *et al.* (2002) conducted an experiment to find out the effect of NAA and Kinetin on plant growth and flower production in carnation cv. Corolla. They reported that combined application of NAA and Kinetin (each @ 100 ppm) recorded significant increase in number of branches per plant (15.87). They also found that application of NAA @ 50 ppm recorded significant increase in plant height (64.8 cm). Whereas NAA at 100 ppm resulted maximum average plant spread (54.53 cm) compared to different concentrations of Kinetin applied on carnation.

Swaroop *et al*. (2007) studied the effect of NAA on African marigold cv. Pusa Narangi Gainda. They reported that application of NAA at 300 ppm recorded increased plant height (79.05 cm) at IARI, New Delhi.

Nandre et *al*. (2009) studied the effect of plant growth regulators on growth, flowering and yield parameters of China aster cv. Poornima. The results revealed that application of NAA at 100 ppm recorded increase in plant height (64.2 cm).

Sudhakar and Kumar (2012) assessed the effect of growth regulators on growth, flowering and corm production of gladiolus (*Gladiolus grandiflorus* L.) cv. White Friendship. They reported that maximum plant height (85.44 cm) was observed with NAA @ 100 ppm and was foundon par with GA_3 @ 100 ppm (84.52 cm).

An experiment was carried out by Palei *et al.* (2016) to find out the effect of plant growth regulators on growth, flowering and yield attributes of African marigold (*Tagetes erecta* L.). The treatments comprising of three doses each of GA_3 (25, 50 and 100 ppm), Ethrel (25, 50 and 100 ppm) and NAA (25, 50 and 100 ppm).They found that minimum plant height (24.32 cm) was observed from plant treated with NAA @ 100 ppm.

Patil *et al.* (2016) conducted a study on response of African marigold var. African Double Orange to plant growth regulators application i.e., GA_3 (100, 200, 300 and 100 ppm) and NAA (100, 200, 300 and 400 ppm). They observed that maximum number of branches per plant (17.60) was found from the plants treated with NAA @ 400 ppm.

2.4 Effect of different concentrations of Naphthalene acetic acid on floral and seed yield parameters

Sooch *et al.* (2002) conducted an experiment to find out the effect of NAA and Kinetin on plant growth and flower production in carnation cv. Corolla. They observed that maximum numbers of flowers per plant (9.87) were observed from the plants applied with NAA @ 100 ppm. Whereas the significant increase in flower size was recorded with single application of NAA @ 25 ppm (7.67 cm).

Swaroop *et al*. (2007) studied the effect of NAA on African marigold cv. Pusa Narangi Gainda. They reported that application of NAA at 300 ppm recorded increase in single flower weight (6.23 g), number of flowers per plant (41.66) and flower yield per plant (357.5 g).

Nandre *et al*. (2009) reported that the number of days to first flower bud appearance (58.33) and days for 50% flowering (71.33) were lowest with NAA at 100 ppm compared to other treatment applied on China aster cv. Poornima. They also reported that flower yield per plant was also found highest (85.25) with NAA at 100 ppm.

Palei *et al.* (2016) carried out an experiment to find out the effect of plant growth regulators on growth, flowering and yield attributes of African marigold (*Tagetes erecta* L.). The treatments comprising of three doses each of GA_3 (25, 50 and 100 ppm) Ethrel (25, 50 and 100 ppm) and NAA (25,50 and 100 ppm).They found that maximum number of days taken to opening of first flower (107.97) and reduced duration of flowering (30.56 days) were found from plant treated with NAA @ 100 ppm.

Patil *et al.* (2016) conducted a study on response of African marigold var. African Double Orange to plant growth regulators application. It was observed that reduced duration of flowering (30.56 days) was found from the plants treated with NAA @ 400 ppm. They also found that increased seed yield per plot; seed per hectare and weight of seeds per flower (975.4 g, 13.16 g and 1.13 g, respectively) were observed from the plants treated with NAA @ 100 ppm and which was found statistically at par with GA_3 @ 300 ppm.

2.5 Effect of different concentrations of Maleic Hydrazide on vegetative parameters

Parmar and Singh (1983) reported that there was significant reduction in number of branches in marigold with MH at 750 and 1000 ppm. They also found that MH at 750 and 1000 ppm concentration also resulted in dwarf plants in China aster.

Lal and Mishra (1986) carried out an investigation to study the effect of MH on vegetative growth parameters of marigold and China aster. They reported that MH at higher concentration of 1000 and 1500 ppm was effective in checking plant growth. They also found that application of MH @ 500 and 1000 ppm recorded significant increase in number of branches.

Shyamal *et al*. (1990) reported that application of MH at 200 ppm recorded significant increase in number of branches per plant in China aster

Kumar and Kumar (2004) studied the effect of MH sprayed at seven different concentrations (0, 50, 100, 250, 400, 500 and 700 ppm) on Balsam (*Impatiens balsamina* L.). They reported that decrease in plant height (63.93 cm) and increase in number of branches per plant (33.73) were recorded from the plants sprayed with a concentration of 700 ppm.

Moond and Rakesh (2006) conducted a study on response of chrysanthemum to application of growth regulators. They reported that Maleic Hydrazide @ 1250 ppm produced minimum plant height (104 cm) and number of laterals (38.8) compared to control.

Joshi and Reddy (2006) investigated the effect of Maleic Hydrazide on the growth of China aster (*Callistephus chinensis*). The treatments consisted of five concentrations of MH, Alar (@150, 300, 600, 900 and 1200 ppm each) and Cycocel (@ 500, 1000, 1500, 2000 and 2500 ppm). They reported that among the different plant growth regulator treatments, Maleic

Hydrazide @ 1200 ppm recorded lowest plant height (30.57 cm). The same treatment also produced lowest internodal length (2.26 cm) but was on par with MH @ 900 ppm (32.27 cm).

Navale *et al.* (2010) studied the effect of growth regulators at different concentrations in chrysanthemum. The results revealed that plant sprayed with MH @ 1250 mg/L recorded minimum plant height (16.4 cm) and number of branches (8.3) and plant spread in terms of both N-S (34.0 cm) and E-W (35.6 cm) as compared to other treatments applied.

Kumar *et al.* (2012) carried out a study on effect of plant growth regulators on growth, yield and exportable quality of cut rose cv. First Red. They revealed that pre harvest application of MH @ 100 ppm resulted in the maximum number of branches per plant (4.47).

Kumar *et al.* (2015) conducted an experiment to study the effect of bio-regulators on growth, flowering and seed yield in China aster [*Callistephus chinensis* (L) Nees] cv. Kamini. Plant growth regulators *viz*., GA_3, Salicylic acid, Maleic Hydrazide, Alar and Paclobutrazol were used in the experiment. It was observed that minimum plant height was obtained from MH spray @ 1100 mg/ L (15.47 cm and 21.13 cm at 30 DAT and 60 DAT, respectively).

Vaghasia and Polara (2015) studied the effect of plant growth retardants on growth, flowering and yield of chrysanthemum (*Chrysanthemum morifolium* Ramat.) cv. IIHR-6. They found that fresh weight of plant (317.55 g) and dry weight of plant (35.87 g) was recorded maximum from the plants applied with MH @ 700 mg L^{-1}.

2.6 Effect of different concentrations of Maleic Hydrazide on floral and seed yield parameters

Shanmugam and Muthuswamy (1974) reported that MH at all concentrations (500, 1000 and 2000 ppm) prolonged the flowering period in white and yellow cv. of chrysanthemum. Similar trend was also found by Reddy and Sulladmath (1983) in China aster with MH @ 1000 ppm concentration and also in *Jasminum grandiflorum* clone Thimmapuram with MH @ 1000, 2000 and 3000 ppm (Pappiah and Muthuswamy, 1977).

Parmar and Singh (1983) registered that application of MH at lower concentration of 500 ppm took minimum number of days taken to initiation of terminal bud (27.7 days) whereas at higher concentration of 1000 ppm took maximum number of days (46.4 days) over untreated plants in marigold.

Nagarjuna *et al*. (1988) reported that flowering was delayed by MH @ 250 and 500 ppm concentration by 17-23 days in comparison with untreated plants in China aster. According to Subramanyam (1988) application of MH @ 400 ppm concentration hastened flowering by 15.3 days over untreated plants in crossandra. Similarly, Aruna (1991) reported earlier flowering by 7 days over control in marigold with MH @ 125 ppm.

Kumar and Kumar (2004) studied the effect of MH sprayed at seven different concentrations (0, 50, 100, 250, 400, 500 and 700 ppm) on Balsam (*Impatiens balsamina* L.). They reported that MH @ 250 ppm recorded more number of flowers per plant (181.20). However, maximum duration of flowering (78.06 days) was observed from the plants sprayed with MH @ 50 ppm.

Kumar *et al*. (2006) reported that among different levels of MH (50, 100 and 150 ppm) tried, 100 ppm was found superior over 50 ppm and 150 ppm levels in respect of spikes per clump (1.63), duration of flowering (37.54 days), number of florets per spike (31.07), fresh weight of spike (40.90 g) and average bulb weight (47.7 g) in tuberose (*Polianthes tuberosa* L.) cv. Pearl Double.

Moond and Rakesh (2006) investigated the response of chrysanthemum to application of growth regulators. They stated that Maleic Hydrazide @ 1250 ppm produced highest number of flowers per plant (371) as compared to control in Chrysanthemum.

The effect of growth regulators at different concentrations in chrysanthemum was studied by Navale *et al.* (2010). The results revealed that plant sprayed with MH @ 1250 mg/L recorded minimum shelf life (14.2 days) and vase life (16.5 days). Whereas the same treatment was also found beneficial for delaying flower opening (98.5 days) and increasing the duration of flowering. However, in case of flower yield per plant (33.3) and per hectare (21.7 t), the lower concentration of MH @ 750 mg/L was found significantly superior as compared to other treatments applied.

Kumar *et al.* (2012) carried out an experiment to study the effect of plant growth regulators on growth, yield and exportable quality of cut rose cv. First Red. They revealed that pre harvest application of MH @ 100 ppm resulted in the maximum number of flowers per plant (16.50).

A field experiment was conducted by Gopichand *et al.* (2014) to study the influence of plant growth regulators, micronutrients and stage of harvesting on seed maturity and quality in African marigold cv. Pusa Narangi Gainda. They found that maximum flower weight (4.42 g), seed yield per flower (0.99 g), number of filled seeds (200.13), thousand seed weight (3.14 g), germination percentage (77.18%), seedling length (8.75 cm) and seedling vigor index (695) were recorded from the plants treated with MH at 1000 ppm + Boron at 0.2%.

The effect of bio-regulators on growth, flowering and seed yield in China aster [*Callistephus chinensis* (L) Nees] cv. Kamini was assessed by Kumar *et al.* (2015). Plant growth regulators *viz*., GA_3, Salicylic acid, Maleic Hydrazide, Alar and Paclobutrazol were used in the experiment. It was observed that increased seed yield per plant, seed yield per hectare and 1000 seed weight were obtained from MH spray @ 1100 mg/ L (9.32 g, 1409.50 Kg and 1.82 g, respectively), MH spray @ 1000 mg/ L (9.17 g, 1386.81 kg and 1.78 g, respectively) and MH spray @ 900 mg/ L (8.78 g, 1327.83 Kg and 1.69 g, respectively) compared to control (5.01 g. 757.68 kg and 1.21 g, respectively).

Vaghasia and Polara (2015) studied the effect of plant growth retardents on growth, flowering and yield of chrysanthemum (*Chrysanthemum morifolium* Ramat.) cv. IIHR-6. They found that fresh weight of plant (317.55 g) and dry weight of plant (35.87 g) were recorded maximum from the plants applied with MH @ 700 mgL^{-1}. Consequently, these plants produced early flowers (70.94 days) with maximum flowering span (46.36 days), flower diameter (6.33 cm), shelf life (5.0 days) as well as vase life (9.05 days) and yield of flowers (13.43 t ha^{-1}).

MATERIALS AND METHODS

CHAPTER 3

MATERIALS AND METHODS

The present study on "Effect of different concentrations of GA_3, NAA and MH on vegetative, floral and yield attributes of China aster [*Callistephus chinensis* (L.) Nees] cv. Poornima" was conducted from March to August 2016. The experiment was based on the evaluation of vegetative, floral and yield characters of China aster. The details of experimental materials used and methods adopted during the course of investigation are described below:

3.1 Experimental Site

The investigation was conducted at the Floriculture and Landscaping block, College of Horticulture, Veer Chandra Singh Garhwali Uttarakhand University of Horticulture and Forestry, Bharsar, District Pauri Garhwal (Uttarakhand) in 2016. Bharsar is situated at the hills of Himalayas at 29^0 20'-29^0 75' N Latitude and 78^0 10'-78^0 80' E Longitude. The altitude of the place is 1900 meter above the mean sea level.

3.2 Prevailing Climatic Conditions

In general, the climate of the Bharsar represents the mild summer, higher precipitation and colder or severe cold prolonged winter. The climate factors *i.e.* precipitation, temperature, relative humidity and wind, in association with elevation (valleys or mountain range from temperate zone), proximity to Great Himalaya, slope aspects, drainage, vegetation etc. are responsible for the micro-climate of this area. Major output of precipitation is in the form of rain fall, besides occasional occurrence of dew, hailstorm, fog, frost, snow fall etc. The South-East monsoon commences towards the end of June while the North-East monsoon causes occasional winter showers during November-February. During winter, snow fall is common in this region. During summer months, Bharsar has hot climate prevailing for few hours in a day, the maximum temperature during May-June is recorded between 23°C-29°C however, and nights are cool. December and January are the coldest months; the minimum temperature reaches to 1°C to -4°C. Relative humidity is normally highest during rainy season (July - August), often recorded near to saturation point (92-97%) and it gradually decreases towards winters.

3.3 Soil Conditions

The soils at Bharsar come under inceptisols. The soil of experimental plot was sandy loam with adequate drainage and optimum water holding capacity. Before laying out the experiment, random soil samples were collected from the furrow slice (0-15 cm depth) of different spots and composite sample was prepared for determination of various soil characteristics.

3.3.1 Nutrient Status of Experimental Area

Sr. No	**Particulars**	**Value obtained**	**Method Employed**
1.	Soil pH	5.5	Digital pH Meter (Jackson, 1973)
2.	Organic carbon (%)	1.13	Rapid Titration Method (Walkley and Black, 1934)
3.	Available N (kg/ha)	206.13	Alkaline Potassium Permanganate method (Subbiah and Asija,1956)
4.	Available P (kg/ha)	32.42	Olsen Method (Olsen *et al*.,1954)
5.	Available K (kg/ha)	243.81	Normal Neutral Ammonium Extract potassium Method (Perur *et al*., 1973)

3.4 Details of Technical Programme

Name of crop	:	China aster
Cultivar	:	Poornima
Experimental design	:	Randomized Complete Block Design
Number of replications	:	Three
Total experimental area	:	49.4 m^2
Plot size	:	90 cm x 90cm
Number of plants per plot	:	Nine
Spacing between plants	:	30 cm x 30 cm
Growing conditions	:	Open field

The treatment details are as follows:

The different concentrations of GA_3, NAA and MH were used according to previous year experiment results that showed concentration of GA_3 and NAA below 200 ppm and MH below 500 ppm had non-significant effect on growth, flowering and yield parameters of China aster cv. Poornima.

T_1	:	Control (no treatment)
T_2	:	GA_3 (100 ppm)
T_3	:	GA_3 (150 ppm)
T_4	:	GA_3 (200 ppm)
T_5	:	GA_3 (250 ppm)
T_6	:	NAA (100 ppm)
T_7	:	NAA (150 ppm)
T_8	:	NAA (200 ppm)
T_9	:	NAA (250 ppm)
T_{10}	:	MH (500 ppm)
T_{11}	:	MH (600 ppm)
T_{12}	:	MH (700 ppm)
T_{13}	:	MH (800 ppm)

Plate 1: View of experimental site

3.5 Experimental material

The experimental material for the present investigation comprised of seeds of China aster cv. Poornima that were obtained from the germplasm being maintained at Department of Floriculture and Landscape Architecture, College of Horticulture, V.C.S.G. U.U.H.F., Bharsar. GA_3, NAA and MH were provided from the laboratory of Floriculture and Landscape Architecture.

3.6 Preparation of solutions

3.6.1 Gibberellic Acid (GA_3)

Solutions of GA_3 100, 200 and 300 ppm were prepared in 1000 ml volumetric flask by dissolving calculated quantity of chemical in small quantity of ethyl alcohol and then volume was made up to one liter with distilled water.

3.6.2 Naphthalene Acetic Acid (NAA)

Solutions of NAA 100, 200 and 300 ppm were prepared in 1000 ml volumetric flasks by dissolving calculated quantity of chemical in small quantity of ethyl alcohol and then volume was made up to one liter with distilled water.

3.6.3 Maleic Hydrazide (MH)

Solutions of MH 500, 750 and 1000 ppm were prepared in 1000 ml volumetric flask by dissolving calculated quantity of chemical in small quantity of ethyl alcohol and then volume was made up to one liter with distilled water.

3.7 Methodology

The experiment was conducted at Floriculture and Landscaping block, College of Horticulture, Veer Chandra Singh Garhwali Uttarakhand University of Horticulture and Forestry,Pauri Garhwal, Bharsar (Uttarakhand). The experiment consisted of thirteen treatments with three

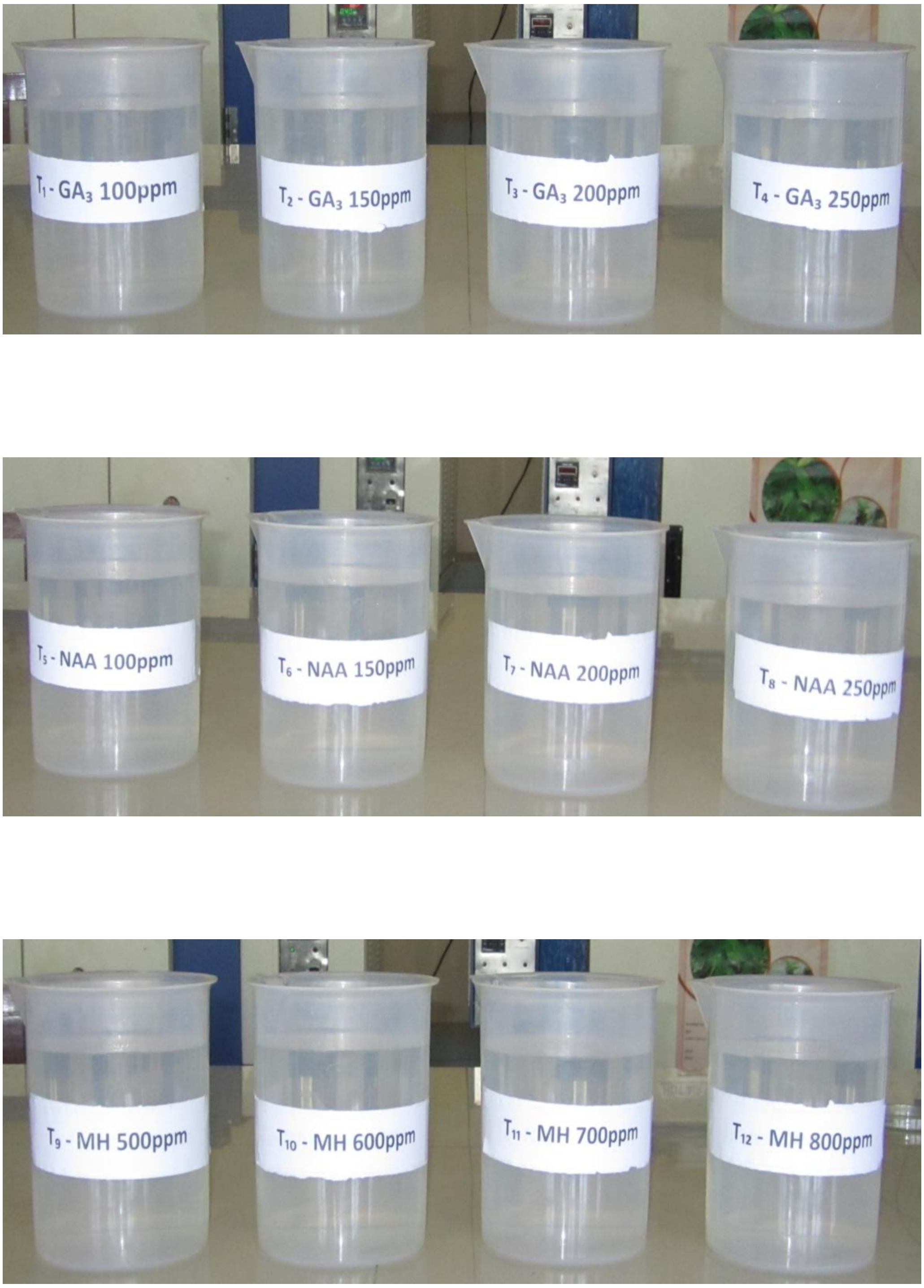

Plate 2: Prepared solution of different concentrations of GA_3, NAA and MH

Plate 3: Foliar spray of treatments

replications. The experiment was plotted according to Randomized Complete Block Design (Gomez and Gomez, 1984). Poornima is a popular cultivar of China aster was chosen for current investigation. Uniform size seedlings at 3-4 leaves stage were transplanted in open field conditions. The prepared solutions were sprayed with the help of hand sprayer, uniformly as per the treatments immediately after preparation at 25 and 50 days after transplanting of seedlings.

3.8 Raising of Seedlings

The seeds of China aster cv. Poornima were sown on raised beds in the first week of March, 2016. The size of nursery beds was 1.0 m x 1.0 m x 0.15 m. Seeds were sown in lines at a spacing of 5- 6 cm and at a depth of 0.5 cm. After sowing, seeds were covered with soil mixed with forest litter. Watering was done twice a day. Thinning and weeding operations were done at regular intervals. Seedlings were ready to transplanting after one month.

3.9 Preparation of Experimental Site and Planting

The land was brought to a fine tilth by two deep ploughings with a power tiller. Before leveling of experimental field, all weeds and leftover crop residues were removed. A spacing of 30 cm between two sub-plots was provided for irrigation channels and working space. The planting of healthy and uniform sized seedlings was done in raised beds of size (90 cm x 90 cm) on first week of April, 2016. The seedlings were planted at a spacing of 30 cm x 30 cm from plant to plant and row to row to accommodate nine plants per bed. The plants were watered immediately after planting and at daily intervals during growing period. Hoeing was done after transplanting as and when needed to get rid of weeds and to aerate the soil. Standard cultural practices were followed uniformly for all the experimental plots. The layout of the experimental site is given in the Fig. 1.

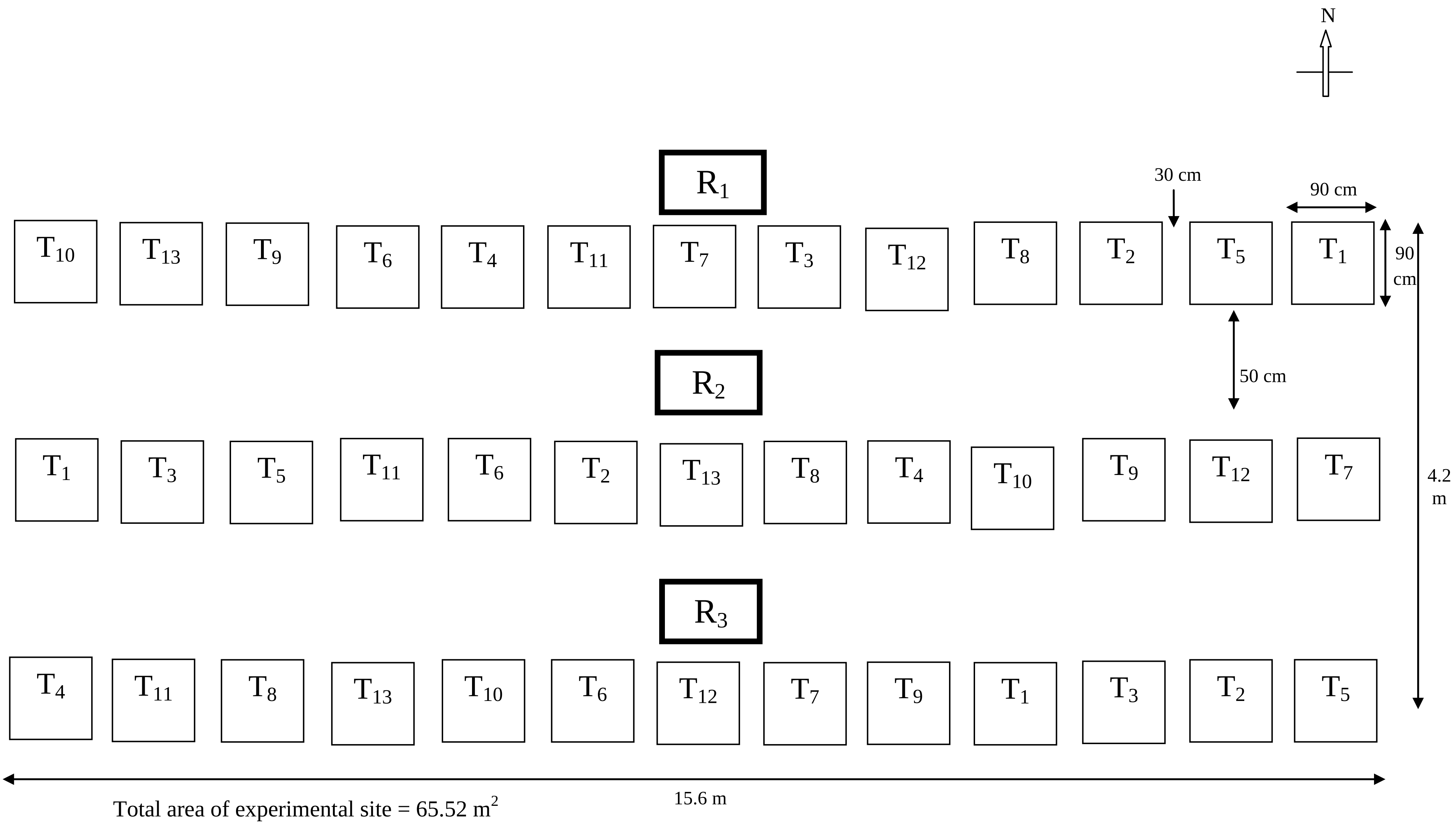

Fig. 1: Layout of the experimental site

3.10 Preparation of Vase Life Studies

The flowers were harvested with the help of sharp secateurs during morning hours in fully opened flower stage. Immediately after harvesting, flower stems were kept in a bucket containing water and brought to the laboratory. Each flower stem was given a slant cut at the base to increase the absorption area. Immediately the flower stems were placed in 200 ml vase (conical flask) containing tap water.

3.11 Observations Recorded

The observations were recorded on five selected plants per treatment in each replication and average value was calculated. The following observations on growth and flowering and seed yield characters were recorded:

3.11.1 Vegetative Parameters

3.11.1.1 Plant height (cm)

Plant height was recorded at the time of peak flowering from the base of the plant, *i.e.*, just above the soil level up to the base of apical flower on the tallest shoot with the help of meter scale. Mean plant height was calculated and expressed in centimeters.

3.11.1.2 Plant spread (cm)

Plant spread was recorded at the time of peak flowering with scale from North – South and East-West directions and their mean was calculated and expressed in centimeters.

3.11.1.3 Number of primary branches plant^{-1}

Total numbers of branches attached from main stem per plants were counted at the time of peak flowering and expressed as average number of primary branches per plant.

3.11.1.4 Number of secondary branches plant^{-1}

Total numbers of branches attached from primary branches per plants were counted at the time of peak flowering and expressed as average number of secondary branches per plant.

3.11.1.5 Number of leaves plant^{-1}

From each of the randomly selected plants, in an individual treatment the number of leaves per plant were counted at the time of peak flowering. Mean value was recorded as number of leaves per plant.

3.11.1.6 Leaf area (cm^2)

Leaf area was recorded with the help of leaf area meter and their mean values were expressed in square centimeters.

3.11.2 Floral Parameters

3.10.2.1 Days taken to first flower bud initiation

Numbers of days required for bud initiation were counted from transplanting up to the stage till first flower bud on a plant becomes visible.

3.11.2.2 Days taken to first flower bud opening

Numbers of days required for flower bud opening were counted from transplanting up to the stage when flower bud on the plant was open.

3.11.2.3 Duration of flowering (days)

Duration of flowering was recorded from peak flowering when 60-70% flowers were fully open up to the stage till it remained in presentable form.

3.11.2.4 Stalk length of flower (cm)

Length of stalk was measured from the base of stem to the base of apical flower with the help of a scale and expressed in centimeters.

3.11.2.5 Diameter of flower (cm)

Flower diameter was measured at the time of peak flowering as average of the distance apices of petal in East or West direction between apices of petal in North to South direction and expressed in centimeters.

3.11.2.6 Flower weight (g)

Weight of single flower picked in morning hours was taken with the help of an electronic balance averaged and expressed in gram.

3.11.2.7 Total number of flowers plant^{-1}

Numbers of flowers per plant were counted when all buds on a plant were fully open.

3.11.2.8 Total number of flowers plot^{-1}

The numbers of flowers per plot were counted and reported on mean basis.

3.11.2.9 Vase life (days)

The day when 50 per cent of ray florets were wilted was taken as terminal day of vase life with respect to a particular treatment. The number of days were counted from the day of placing the flower stalk in the vase to the terminal day and expressed as vase life in days.

3.11.2.10 Shelf life (days)

Five randomly selected flowers from each treatment were kept in tray under ambient room temperature condition. The numbers of days were counted from the day of placing the flowers to till the 50 per cent of ray florets were wilted.

3.11.3 Yield Parameters

3.11.3.1 Seed yield plant^{-1}(g)

The weight of total number of seeds harvested from tagged plants were taken with the help of electronic balance, averaged and expressed in gram.

3.11.3.2 Seed yield plot^{-1}(g)

The weight of total seeds collected from per plot was taken with the help of an electronic balance and expressed in gram.

3.11.3.3 Test weight (g)

The weight of 1000 seeds collected from per treatment was taken with the help of electronic balance and expressed in gram.

3.12 Statistical Analysis

The data were statistically analyzed by using Randomized Complete Block Design. The significance of difference among treatment means were tested by F-test. Wherever, the F- test was found to be significant, critical difference (CD) at 5 per cent level of significance was calculated. The results are presented in the forms of graphs and tables and are given at appropriate place for result interpretation.

3.12.1 Analysis of variance

The table for analysis of variance (ANOVA) was set as explained by Gomez and Gomez (1984).

Source of variation	**Degree of freedom**	**Sum of squares**	**Mean sum of squares**	**F calculated value**
Replication(r)	(r-1)	Sr	Sr/r-1 = Mr	Mr/Me
Treatment (t)	(t-1)	St	St/t-1 = Mt	Mt / Me
Error (E)	(r-1) (t-1)	Se	Se/(r-1)(t-1) = Me	

Where,

R = Number of replications

T = Number of treatments

Sr = Sum of square due to replications

St = Sum of square due to treatments

Se = Sum of square due to error

Mr = Mean sum of square due to replication

Mt = Mean sum of square due to treatment

Me = Mean sum of square due to error

The calculated ‘f’ value was compared with the tabulated F value. If F-test was found significant, then standard error and critical difference were calculated as under:

SEm$\pm$ = $\sqrt{(Me/r)}$

SEd$\pm$ = $\sqrt{(2Me/r)}$

C.D. (5%) = SEd x t 0.05 error d.f.

Where,

SEm$\pm$ = Standard error of mean

SEd$\pm$ = Standard error of difference

C.D. (5%) = Critical difference at 5% level of significance

RESULTS

CHAPTER 4

RESULTS

The experimental findings of the present investigation entitled "Effect of different concentrations of GA_3, NAA and MH on vegetative, floral and yield attributes of China aster [*Callistephus chinensis* (L.) Nees] cv. Poornima" are presented in this chapter under the following subheadings with the help of Tables. The analysis of variance of different parameters under study have been given in appendices.

4.1 Effect of different concentrations of GA_3, NAA and MH on vegetative parameters

4.1.1 Plant height (cm)

An exploratory experiment with thirteen treatments was conducted to see the effect of different concentrations of GA_3, NAA and MH on plant height. On perusal of data tabulated in Table 4.1(i) it is evident that maximum plant height (85.69 cm) was observed from the plants sprayed with GA_3 @ 200 ppm and which was recorded statistically at par with GA_3 @ 150 ppm (82.46 cm). However, the plants grown in control plots recorded plant height of 65.80 cm. Data revealed that different concentrations of GA_3 recorded significant increase in plant height as compared to control. Among the different concentrations of NAA applied NAA concentrations @ 200 ppm and @ 250 ppm recorded significant increase in plant height (70.46 cm and 72.10 cm, respectively) as compared to control. However, data showed that plants sprayed with NAA @ 100 ppm and 150 ppm showed statistically at par plant height with control. Among the different concentrations of GA_3 & NAA applied, GA_3 @ 200 ppm & 150 ppm was found best in term of increase in plant height. Data showed that plants sprayed with different concentrations of MH had minimum plant height in MH @ 800 ppm (53.38 cm). This was found statistically at par with MH @ 700 ppm (55.74 cm). Data revealed that different concentrations of MH significantly reduced plant height as compared to control.

4.1.2 Number of primary branches plant^{-1}

The data pertaining to the effect of different concentrations of GA_3, NAA and MH on the number of primary branches of China aster cultivar Poornima are depicted in Table 4.1(i). Data showed that maximum number of primary branches plant^{-1} (18.36) was recorded from the plants sprayed with GA_3 @ 250 ppm and which was found statistically at par with the plants applied with MH @ 500 ppm (17.66) and GA_3 @ 200 ppm (17.53). However, minimum number of primary branches plant^{-1} (10.74) was observed from the plants grown in control. Data revealed that all the applied concentrations of GA_3 recorded significant increase in number of primary branches plant^{-1} as compared to control. Whereas plants sprayed with different concentrations of NAA showed statistically at par results in terms of number of primary branches plant^{-1}with control. In case of MH all the concentrations of MH applied showed significant increase in number of primary branches plant^{-1} as compared to control. Among them, application of MH @ 500 ppm recorded maximum number of primary branches plant^{-1}(17.66).

4.1.3 Number of secondary branches plant^{-1}

The perusal of data presented in Table 4.1(i) revealed that maximum number of secondary branches plant^{-1} (35.83) was recorded from plants sprayed with GA_3 @ 200 ppm followed by GA_3 @ 250 ppm (32.50). However, plants grown in control plots recorded minimum number of secondary branches plant^{-1}(18.73). Data revealed that all the concentrations of GA_3 significantly increased the number of secondary branches plant^{-1} over control. Among the different concentrations of NAA applied, NAA @ 250 ppm (21.20) recorded significant increase in number of secondary branches plant^{-1} (21.20) as compared to control. However, data showed that plants sprayed with NAA @ 100 ppm, 150 ppm and 200 ppm showed statistically at par results in terms of number of secondary branches plant^{-1}with control. In the terms of number of secondary branches plant^{-1} application of GA_3 @ 200 ppm and GA_3 @ 250 ppm was found best among the different concentrations of GA_3 and NAA applied. The data indicated that different concentrations of MH significantly increased the number of secondary branches plant $^{-1}$ over control except T_{13} (20.73). Among different concentrations of MH applied, plants sprayed with MH @ 500 ppm recorded maximum number of secondary branches plant^{-1}(30.68).

Table 4.1(i): Effect of different concentrations of GA_3, NAA and MH on plant height (cm), number of primary branches $plant^{-1}$ and number of secondary branches $plant^{-1}$ of China aster cv. Poornima.

Treatments	Plant height (cm) ± S.E(m)	No. of primary branches $plant^{-1}$ ± S.E(m)	No. of secondary branches $plant^{-1}$ ± S.E(m)
T_1 (Control)	65.80 ± 0.62	10.74 ± 0.24	18.73 ± 0.44
T_2 (GA_3 100 ppm)	79.90* ± 2.27	15.83* ± 0.14	27.19* ± 0.93
T_3 (GA_3 150 ppm)	82.46* ± 1.36	15.93* ± 0.29	25.80* ± 1.42
T_4 (GA_3 200 ppm)	85.69* ± 2.77	17.53*± 0.29	35.83* ± 0.43
T_5 (GA_3 250 ppm)	76.59* ± 1.38	18.36* ± 0.43	32.50* ± 0.55
T_6 (NAA 100 ppm)	66.18 ± 0.65	11.03 ± 1.33	20.51 ± 1.04
T_7(NAA 150 ppm)	69.59 ± 1.42	11.74 ± 0.84	19.60 ± 0.66
T_8 (NAA 200 ppm)	70.46* ± 2.37	12.02 ± 0.13	18.77 ± 0.50
T_9 (NAA 250 ppm)	72.10* ± 2.01	12.54 ± 0.33	21.20* ± 0.95
T_{10} (MH 500 ppm)	59.18* ± 1.00	17.66*± 0.28	30.68* ± 0.80
T_{11} (MH 600 ppm)	57.74* ± 0.99	13.23*± 0.21	28.06*± 0 .26
T_{12} (MH 700 ppm)	55.74* ± 0.95	13.56*± 0.20	24.33* ± 0.92
T_{13} (MH 800 ppm)	53.38* ± 1.11	14.82* ± 1.12	20.73 ± 0.82
S.E(d)	2.10	0.87	1.09
$C.D_{(0.05)}$	4.34	1.81	2.25

***Significant at 5% level of significance with control**

4.1.4 Plant spread (cm)

Perusal of data pertaining to the effect of different concentrations of GA_3, NAA and MH on plant spread of China aster cv. Poornima is depicted in Table 4.1(ii). Data revealed that the maximum plant spread (33.95 cm) was observed from the plants sprayed with GA_3 @ 200 ppm and which was found statistically at par GA_3 @ 250 ppm (31.95 cm). However the plants grown in control plots recorded minimum plant spread (22.88 cm). Data revealed that all the concentrations of GA_3 significantly increased the plant spread over control. Among the different concentrations of NAA applied, NAA @ 100 ppm and NAA @ 250 ppm recorded significant increase in plant spread (25.53 cm and 25.72 cm, respectively) as compared to control. However, plants sprayed with NAA 150 ppm and 200 ppm recorded statistically at par results in terms of plant spread (24.45 cm and 24.67 cm, respectively) with control. Among different concentration of GA_3 and NAA, GA_3 @ 200 ppm and 250 ppm recorded increase in plant spread as compared to other treatments applied. Data showed that all applied concentrations of MH sprayed significantly increase the plant spread as compared to control. In different concentrations of MH applied, maximum plant spread (28.73 cm) recorded in MH @ 500 ppm and which was found statistically at par with plants sprayed with MH 600 ppm (27.07 cm).

4.1.5 Number of leaves plant^{-1}

The data pertaining to the effect of different concentrations of GA_3, NAA and MH on number of leaves plant^{-1} is presented in Table 4.1(ii). Data showed that plants applied with GA_3 @ 250 ppm produced maximum number of leaves plant^{1}(322.76) which was found statistically at par with the plants applied with treatment NAA @ 200 ppm, GA_3 @ 200 ppm and NAA @ 250 ppm (320.45, 315.28 and 303.12 respectively). However, the plants grown in control plots produced 240.24 leaves plant^{-1}. Data revealed that GA_3 @ 100 ppm was found at par with control. Among the different concentrations of NAA applied all the treatments significantly increased the number of leaves plant^{-1} compared to control. Data revealed that plants sprayed with different concentrations of MH produced minimum numbers of leaves plant^{-1} (189.38) in MH @ 800 ppm which was found statistically at par with MH @ 700 ppm (198.08). It was observed that two concentrations of MH @ 500 ppm & 600 ppm recorded statistically at par with control.

4.1.6 Leaf area (cm^2)

On perusal of data tabulated in Table 4.1(ii) the maximum leaf area (12.68 cm^2) was recorded from the plants sprayed with GA_3 @ 100 ppm (T_2). The minimum leaf area (8.45cm^2) was recorded from the plants sprayed with NAA @ 200 ppm (T_8). However data showed that application of different concentrations of GA_3, NAA and MH showed at par results with the control in respect to leaf area of China aster cv. Poornima.

Table 4.1(ii): Effect of different concentrations of GA_3, NAA and MH on plant spread (cm), number of leaves plant^{-1} and leaf area (cm^2) of China aster cv. Poornima.

Treatments	Plant spread (cm) ± S.E(m)	No. of leaves plant^{-1} ± S.E(m)	Leaf area (cm^2) ± S.E(m)
T_1(Control)	22.88 ± 0.69	240.24 ± 3.24	11.32 ± 0.72
T_2 (GA_3 100 ppm)	29.87* ± 0.68	256.53 ± 6.96	12.68 ± 1.47
T_3 (GA_3 150 ppm)	29.09* ± 0.40	264.51* ± 7.74	10.58 ± 1.16
T_4 (GA_3 200 ppm)	33.95* ± 0.73	315.18* ±13.73	11.60 ± 0.65
T_5 (GA_3 250 ppm)	31.95* ± 0.41	322.76* ± 8.64	10.59 ± 2.01
T_6 (NAA 100 ppm)	25.53* ± 1.08	293.73* ± 7.84	10.22 ± 0.97
T_7 (NAA 150 ppm)	24.45 ± 0.63	269.99* ± 7.45	10.75 ± 0.78
T_8 (NAA 200 ppm)	24.67 ± 0.63	320.45* ± 14.22	8.45 ± 1.39
T_9 (NAA 250 ppm)	25.72* ± 1.60	303.12* ± 12.71	11.81 ± 1.32
T_{10} (MH 500 ppm)	28.73* ± 1.57	230.32 ± 11.34	9.63 ± 1.82
T_{11} (MH 600 ppm)	27.07* ± 1.71	220.77 ± 8.94	8.82 ± 0.52
T_{12} (MH 700 ppm)	25.96* ± 0.67	198.08* ± 3.5	11.03 ± 1.36
T_{13} (MH 800 ppm)	25.84* ± 0.77	189.38* ± 3.27	10.18 ± 1.03
S.E(d)	1.09	9.94	1.64
$C.D_{(0.05)}$	2.26	20.51	3.38

***Significant at 5% level of significance with control**

4.2 Effect of different concentrations of GA_3, NAA and MH on floral parameters

4.2.1 Days taken to first flower bud initiation

The data pertaining to the effect of different concentrations of GA_3, NAA and MH on days taken to first flower bud initiation of China aster cultivar Poornima is depicted in Table 4.2(i). Data revealed that minimum days taken to flower bud initiation (57.19) were recorded from the plants sprayed with GA_3 @ 200 ppm (T_4). It was found statically at par with GA_3 @ 100 ppm and GA_3 @ 150 ppm (58.00 days and 58.10 days, respectively). However, the plants grown in control plots took 70.20 days for first flower bud initiation. Data showed that different concentrations of GA_3 recorded significant earliness in first flower bud initiation as compared to control. Among all the treatments applied, plants sprayed with NAA @ 250 ppm took maximum days (75.23) to first flower bud initiation and was statistically at par with NAA @ 150 ppm (73.91 days). Data also revealed that plant sprayed with NAA @100 and 200 ppm showed statically at par result with each other with respect to days taken to first flower bud initiation (72.80 days and 72.33 days, respectively).The different concentrations of NAA applied significantly delayed the first bud initiation as compared to control. It was observed that all the treatments containing MH significantly reduced the days taken to first flower bud initiation. Among different concentrations MH applied, MH @ 500 ppm recorded minimum days taken to first flower bud initiation (63.73) and which was found statistically at par with MH @ 600 ppm and 800 ppm (64.82 days and 64.30 days, respectively).

4.2.2 Days taken to first flower bud opening

Data recorded on effect of different concentrations of GA_3, NAA and MH on days taken to first flower bud opening is depicted in table 4.2(i). Data presented in table revealed that minimum days taken to first flower bud opening (83.56) was recorded from the plants sprayed with GA_3 @ 200 ppm which was found statistically at par with the plants treated with GA_3 @ 150 ppm and 100 ppm (85.16 days and 85.29 days, respectively). However plants grown in control plots took 99.86 days for first flower bud opening. Data indicated that different concentrations of GA_3 recorded significant decrease in days taken to first flower bud opening compared to control. Data showed that maximum days for first flower bud opening were recorded from the plants sprayed with flowering NAA @ 250 ppm which took 107.39 days. Among the different concentrations of NAA sprayed, all the treatments recorded significant delay in days taken to first flower bud opening compared to control. Data also revealed that the plants treated with different concentrations of MH also recorded significant earliness in flowering as compared to control. The plants sprayed with different concentration of MH recorded statistically at par results with each other with respect to days taken to first flower bud opening.

4.2.3 Duration of flowering (Days)

The data pertaining to the effect of different concentrations of $GA_{3,}$ NAA and MH on duration of flowering of China aster cultivar Poornima are given in Table 4.2 (i). The maximum duration of flowering (28.11 days) was recorded from the plants sprayed with GA_3 @ 200 ppm (T_4). However, minimum duration of flowering (15.67 days) was observed from the plants grown in the control and which was recorded statistically at par with treatment containing MH @ 800 ppm (17.78 days). Data indicated that different concentrations of GA_3 recorded significant increase in days taken to flowering compared to control. The plants sprayed with GA_3 @ 250, 150 and 100 ppm showed statistically at par results in terms of duration of flowering with each other (24.68 days, 23.99 days and 23.41 days, respectively). The different concentrations of NAA applied, all the treatments recorded significant increase in duration of flowering with as compared to control (T_1). Among them NAA @ 100 ppm recorded maximum duration of flowering (22.53 days) and which was found statistically at par with treatment containing NAA @ 150 ppm (22.07 days). Among different concentrations of GA_3 and NAA sprayed GA_3 @ 200 ppm significantly improve duration of flowering. Plants treated with different concentrations of MH also showed increase in duration of flowering as compared to control except MH @ 800 ppm. Data also revealed that plants sprayed with MH @ 500 ppm, 600 ppm and 700 ppm were found statistically at par with each other (19.45 days, 18.21 days and 18.80 days, respectively).

4.2.4 Stalk length (cm)

On perusal of data presented on Table 4.2(i) data revealed that maximum stalk length of the flower (39.82cm) was observed from plants sprayed with GA_3 @ 200 ppm. However, plants grown in control plots recorded stalk length of 29.51 cm. Data indicated that different concentrations of GA_3 recorded significant increase in stalk length as compared to control. The plants sprayed with GA_3 @ 150 ppm and 250 ppm recorded statistically at par with respect to stalk length (37.95 cm and 37.94 cm, respectively). Among different concentrations of NAA applied, all the treatments recorded significant increase in stalk length compared to control. The data showed that NAA @ 250 ppm, 200 ppm and 150 ppm showed statistically at par results with each other (33.29 cm, 33.02 cm and 32.43 cm, respectively). Data showed that among different concentrations of GA_3 and NAA applied, GA3 @ 200 ppm recorded significant increase in stalk length of flower. The plants sprayed with different concentrations of MH produced significant reduction in stalk length as compared to control except plants sprayed with MH @ 500 ppm (27.87 cm). Data revealed that stalk length of plants sprayed with MH @ 600 ppm, 700 ppm and 800 ppm showed statistically at par with each other (27.21 cm, 26.74 cm and 26.19 cm, respectively).

Table 4.2(i): Effect of different concentrations of GA_3, NAA and MH on number of days taken to flower bud initiation, days taken to first flower bud opening, duration of flowering (days) and stalk length (cm) of China aster cv. Poornima.

Treatments	Days taken to flower bud initiation ± S.E(m)	Days taken to first flower bud opening ± S.E(m)	Duration of flowering (days) ± S.E(m)	Stalk length of flower (cm) ± S.E(m)
T_1(Control)	70.20 ± 1.31	99.86 ± 1.22	15.67 ± 0.89	29.51± 0.88
T_2 (GA_3 100 ppm)	58.00* ± 0.30	85.29* ± 0.66	23.41* ± 1.04	36.27* ± 1.18
T_3 (GA_3 150 ppm)	58.10* ± 0.25	85.16* ± 0.34	23.99* ± 1.28	37.95* ± 0.77
T_4 (GA_3 200 ppm)	57.19* ± 0.52	83.56* ± 1.16	28.11* ± 1.58	39.82* ± 0.29
T_5(GA_3 250 ppm)	60.46* ± 0.17	87.33* ± 1.04	24.68* ±1.04	37.94* ± 0.28
T_6(NAA 100 ppm)	72.80* ± 0.72	102.40* ± 1.10	22.53* ± 0.92	31.57* ± 0.91
T_7 (NAA 150 ppm)	73.91* ± 0.90	102.33* ± 0.69	22.07* ± 0.77	32.43* ± 0.91
T_8(NAA 200 ppm)	72.33* ± 0.69	104.06* ± 0.72	20.55* ± 0.15	33.02* ± 0.97
T_9(NAA 250 ppm)	75.23* ± 0.52	107.39* ± 0.57	20.09* ±0.75	33.29* ± 0.58
T_{10}(MH 500 ppm)	63.73* ± 0.43	92.91* ± 0.34	19.45* ± 0.69	27.87 ± 0.53
T_{11}(MH 600 ppm)	64.82* ± 0.06	91.86* ± 0.77	18.21* ± 0.55	27.21* ± 1.00
T_{12}(MH 700 ppm)	66.37* ± 0.23	93.10* ± 0.37	18.80* ± 0.50	26.74* ± 0.44
T_{13}(MH 800 ppm)	64.30* ± 0.55	93.36* ± 0.39	17.78 ± 0.37	26.19* ± 0.23
S.E(d)	0.88	0.90	1.07	0.80
$C.D_{(0.05)}$	1.83	1.88	2.21	1.66

***Significant at 5% level of significance with control**

Plate 4: Flower bud initiation and opening

Plate 5: Maximum stalk length with GA_3 200 ppm

4.2.5 Flower diameter (cm)

Data recorded in Table 4.2(ii) summarizes the effect of different treatments on flower diameter. Data revealed that maximum flower diameter (8.80 cm) was recorded from the plant sprayed with GA_3 @ 200 ppm (T_4) which showed statistically at par result with the plant applied with GA_3 @ 150 ppm (8.66 cm) and GA_3 @ 100 ppm (8.57 cm). However, plants grown in control plots recorded flower diameter of 7.57 cm. Data indicated that different concentrations of GA_3 recorded significant increase in flower diameter as compared to control. The different concentrations of NAA recorded statistically at par results with control. It is evident from the data that among the different concentrations of GA_3 and NAA applied; all the applied concentrations of GA_3 recorded the best results. The minimum flower diameter (6.24 cm) was recorded from the plants sprayed with MH @ 800 ppm (T_{13}) which was found statistically at par with the plant sprayed with MH @ 700 ppm, 500 ppm and 600 ppm (6.51 cm, 6.54 cm and 6.48 cm, respectively). The data revealed indicated that all the applied concentrations of MH significantly reduce the flower diameter as compared to control.

4.2.6 Flower weight (g)

The data pertaining to the effect of different concentrations of GA_3, NAA and MH on flower weight is given in Table 4.2(ii). The data revealed that maximum flower weight (5.16 g) was found from the flowers harvested from the plants sprayed with GA_3 @ 200 ppm (T_4). However plants grown in control plots recorded flower weight of 3.96 g. Data indicated that different concentrations of GA_3 recorded significant increase in flower weight as compared to control. The different concentrations of NAA applied showed statistically at par results with control. Among the different concentrations of GA_3 and NAA, significant increase in flower weight was recorded in the plants sprayed with GA_3 @ 200 ppm. Data indicated that minimum flower weight (3.38 g) was obtained from the flowers harvested from the plants applied with treatment (T_{13}) containing MH @ 800 ppm. It was found statistically at par with T_{12} and T_{11} (3.52 g and 3.64 g, respectively). Data revealed that all the applied concentrations of MH showed significant reduction in flower weight except MH @ 500 (3.83 g) which was found statistically at par with control.

4.2.7 Number of flowers plant^{-1}

Data recorded on total number of flowers plant^{-1} depicted in Table 4.2(ii) revealed that the maximum number of flowers plant^{-1} (48.76) were recorded from the plants sprayed with GA_3@ 200 ppm i.e. T_4. Minimum number of flowers plant^{-1} (23.87) was noticed from the plants grown in control (T_1). Data revealed that different concentrations of GA_3 recorded significant increase in number of flowers plant^{-1} as compared to control. Among the different concentrations of NAA applied, NAA @ 100 ppm significantly increased the number of flowers plant^{-1} (30.32) whereas others (NAA @ 150 ppm, NAA @ 200 ppm and NAA @ 250 ppm) were found statistically at par with the control. It is evident from the data presented that among all the treatments of GA_3 and NAA, GA_3@ 200 ppm showed the best results in terms of number of flowers plant^{-1}. In case of MH all the concentrations of MH showed significantly increased number of flowers plant^{-1} in which MH @ 500 ppm produced maximum (33.69) number of flowers plant^{-1}.

4.2.8 Number of flowers plot^{-1}

On perusal of data tabulated in Table 4.2(ii) it is evident that the maximum number of flowers plot^{-1}(418.56) were observed from the plants sprayed with treatment containing GA_3@ 200 ppm (T_4) which was found statistically at par with the plots treated with GA_3 @100 ppm (378.64) i.e. T_2. Minimum numbers of flowers plot^{-1} (207.86) were observed from the plants grown in control. Among different concentrations of NAA applied, all the treatments NAA @ 200 ppm (221.46), NAA @ 150 ppm (230.54) and NAA @ 250 ppm (235.31) were found statistically at par with the control except NAA @ 100 ppm which significantly increased number of flowers plot^{-1}(264.54) as compared to control. Data showed that different concentrations of GA_3 showed better results compared to NAA in terms of numbers of flowers plot^{-1}. Data showed that all treatments containing MH recorded significantly increased number of flowers plot^{-1} and all the concentrations of MH (500 ppm, 600 ppm, 700 ppm and 800 ppm) were found statistically at par with each other (295.24, 283.49, 266.82 and 291.98, respectively).

Table 4.2(ii): Effect of different concentrations of GA_3, NAA and MH on flower diameter (cm), flower weight (g), number of flowers $plant^{-1}$ and number of flowers $plot^{-1}$ of China aster cv. Poornima.

Treatments	Flower diameter (cm) ± S.E(m)	Flower weight (g) ± S.E(m)	Number of flowers $plant^{-1}$ ± S.E(m)	Number of flowers $plot^{-1}$ ± S.E(m)
T_1 (Control)	7.57 ± 0.14	3.96 ± 0.17	23.87 ± 1.38	207.86 ± 10.43
T_2(GA_3 100 ppm)	8.57* ± 0.17	4.58* ± 0.12	42.29* ± 1.74	378.64* ± 13.27
T_3(GA_3 150 ppm)	8.66* ± 0.20	4.73* ± 0.49	39.88* ± 0.69	341.31* ± 12.40
T_4(GA_3 200 ppm)	8.80* ± 0.05	5.16* ± 0.12	48.76* ± 1.05	418.56* ± 6.12
T_5(GA_3 250 ppm)	8.27* ± 0.09	4.44* ± 0.14	38.86* ± 1.26	351.07* ± 10.95
T_6(NAA 100 ppm)	7.42 ± 0.25	3.89 ± 0.02	30.32* ± 3.20	264.54* ± 26.32
T_7(NAA 150 ppm)	7.51 ± 0.16	3.79 ± 0.04	26.72 ± 0.57	230.54 ± 4.74
T_8(NAA 200 ppm)	7.53 ± 0.19	3.82 ± 0.07	25.20 ± 0.49	221.46 ± 2.38
T_9(NAA 250 ppm)	7.63 ± 0.13	4.10 ± 0.13	27.22 ± 1.11	235.31± 8.79
T_{10}(MH 500 ppm)	6.54* ± 0.20	3.83 ± 0.08	33.69* ± 1.56	295.24* ± 14.29
T_{11}(MH 600 ppm)	6.48* ± 0.13	3.64* ± 0.04	31.87* ± 2.00	283.49* ± 24.77
T_{12}(MH 700 ppm)	6.51* ± 0.15	3.52* ± 0.13	29.64* ± 2.40	266.82* ± 28.59
T_{13}(MH 800 ppm)	6.24* ± 0.11	3.38* ± 0.09	33.14* ± 2.80	291.98* ± 22.85
S.E(d)	0.23	0.15	2.57	23.86
$C.D_{(0.05)}$	0.48	0.31	5.35	49.55

***Significant at 5% level of significance with control**

4.2.9 Vase life (Days)

Vase life is the period for which flowers remain in presentable form in vase without losing its grade and quality. An exploratory experiment with different concentrations of growth regulators GA_3, NAA and MH was conducted to see their effect on the vase life. It is evident from Table 4.2(iii) that maximum vase life (10.66 days) was found from flowers harvested from the plants sprayed with GA_3 @ 250 ppm (T_5). The plants treated with GA_3 @

200 ppm, GA_3 @ 150 ppm, GA_3 @ 100 ppm and NAA @ 100 ppm (10.33 days, 10.00 days, 10.00 days and 10.00 days, respectively) showed statistically at par results with (T_5). However minimum vase life (6.66 days) was recorded in flowers harvested from plants grown in control plots (T_1). Data showed that different concentrations of GA_3 and NAA applied showed significant increase in vase life as compared to control. The flowers harvested from the plants treated with MH @ 700 ppm and MH @ 800 ppm showed significant increase in vase life (8.00 days and 8.33 days, respectively) as compare to control. Data also revealed that flowers harvested from the plants treated with MH @ 500 ppm and MH @ 600 ppm showed statistically at par results in terms of vase life as cut flowers (7.33 days and 7.66 days, respectively) with control (T_1).

4.2.10 Shelf life (days)

The data of effect of different concentrations of GA_3, NAA and MH on shelf life of flowers is presented in table 4.2(iii). The data revealed that flowers harvested from the plants sprayed with GA_3 @ 250 ppm (T_5) recorded maximum shelf life (3.66 days) and which was found to be statistically at par with treatments GA_3 @ 200 ppm, GA_3 @ 150 ppm, GA_3 @ 100 ppm and NAA @ 200 ppm (3.33, 3.33, 3.00 and 3.00 days respectively). However, minimum shelf life (1.66 days) was recorded from flowers harvested from the plants grown in control (T_1). Among different concentrations of NAA applied, all the treatments significantly increased the vase life over control except NAA @ 150 ppm which was found statistically at par with control. Data also showed that plants sprayed with MH @ 700 ppm and NAA @ 100 ppm recorded exactly same shelf life i.e., 2.66 days. Among different concentrations of MH sprayed except MH @ 700 ppm other concentration recorded statistically at par with control in terms of in shelf life.

Plate 6: Observation of vase life and shelf life

Table 4.2(iii): Effect of different concentrations of GA_3, NAA and MH on vase life (days) and shelf life (days) of China aster cv. Poornima.

Treatments	Vase life (days) ± S.E(m)	Shelf life (days) ± S.E(m)
T_1 (Control)	6.66 ± 0.33	1.66 ± 0.33
T_2(GA_3 100 ppm)	10.00* ± 0.57	3.00* ± 0.00
T_3(GA_3 150 ppm)	10.00* ± 0.00	3.33* ± 0.33
T_4(GA_3 200 ppm)	10.33* ± 0.66	3.33* ± 0.33
T_5(GA_3 250 ppm)	10.66* ± 0.33	3.66* ± 0.33
T_6(NAA 100 ppm)	10.00* ± 0.57	2.66* ± 0.33
T_7(NAA 150 ppm)	9.66* ± 0.33	2.33 ± 0.33
T_8(NAA 200 ppm)	8.66* ± 0.33	3.00* ± 0.00
T_9(NAA 250 ppm)	9.00* ± 0.00	2.66* ± 0.33
T_{10}(MH 500 ppm)	7.33 ± 0.66	2.00 ± 0.00
T_{11}(MH 600 ppm)	7.66 ± 0.33	2.33 ± 0.33
T_{12}(MH 700 ppm)	8.00* ± 0.00	2.66* ± 0.33
T_{13}(MH 800 ppm)	8.33* ± 0.33	2.33 ± 0.33
S.E(d)	0.54	0.41
$C.D_{(0.05)}$	1.13	0.85

***Significant at 5% level of significance with control**

4.3 Effect of different concentrations of GA_3, NAA and MH on seed yield parameters

4.3.1 Seed yield plant^{-1}

The data pertaining to the effect of different concentrations of GA_3, NAA and MH on the seed yield plant^{-1} of China aster cultivar Poornima is depicted in Table 4.3. Data revealed that maximum seed yield plant^{-1} (6.38 g) was observed from the plants sprayed with T_4 and which was found statistically at par with the seed harvested from plants sprayed with treatment containing GA_3 @ 250 ppm (6.04 g). However, minimum seed yield plant^{-1} (3.16

g) was recorded from the plants grown in the control. Among different concentrations of NAA applied, all the treatments of NAA significantly increased the seed yield plant^{-1} as compared to control and maximum seed yield plant^{-1} was recorded in NAA @ 100 ppm (5.14 g) which was found at par with GA_3 @ 100 ppm (5.44 g). It is evident from the results that GA_3 at different concentrations produced better seed yield plant^{-1} compared to NAA. Data showed that MH @ 600 ppm, MH @ 700 ppm and MH @ 800 ppm also showed significantly increased seed yield plant^{-1} (3.73 g, 4.09 g and 4.34 g, resectively) as compare to control. However, seed harvested from the plants sprayed with MH @ 500 ppm showed statistically at par results with control.

4.3.2 Seed yield plot^{-1}

The effect of different concentrations of GA_3, NAA and MH on seed yield plot^{-1} is presented in Table 4.3. The data pertaining to the effect of different concentrations of GA_3, NAA and MH on the seed yield plot^{-1} of China aster cultivar Poornima revealed that maximum seed yield plot^{-1} (55.86 g) was observed from the plants applied with GA_3 @ 200 ppm followed by GA_3 @ 200 ppm (52.42 g). However minimum seed yield plot^{-1} (25.74 g) was observed from the plants grown in the control. It was noticed that all treatments containing NAA significantly increased seed yield plot^{-1} compared to control in which maximum seed yield was obtained from NAA @ 100 ppm (44.76 g). It is evident in data presented that among different concentrations of GA_3 and NAA applied, all the concentrations of GA_3 showed better result. Data also showed that different concentrations of MH significantly increased the seed yield plot^{-1}, in which maximum seed yield was obtained from MH @ 800 ppm (35.29 g).

4.3.3 Test weight (g)

Data recorded on effect of different concentrations of GA_3, NAA and MH on test weight of seeds depicted in Table 4.3 revealed that the maximum test weight (1.58 g) was recorded from the plants treated with GA_3 @ 200 ppm. However, test weight was recorded minimum (0.99 g) from the seeds harvested from the control plots. All the applied concentrations of GA_3 recorded significant increase in test weight as compared to control. Data showed that seeds harvested from the plants sprayed with GA_3 @ 250 ppm, 150 ppm and 100 ppm showed statistically at par results with each other (1.48 g, 1.43 g and 1.41 g, respectively). It was recorded that all the concentrations of NAA applied showed the significant increase in test weight. Data showed that seeds harvested from the plants sprayed with NAA @ 150 ppm, 100 ppm and 200 ppm recorded statistically at par result with each other in terms of test weight (1.38 g, 1.36 g and 1.34 g, respectively). Among different concentrations of GA_3 and NAA applied, NAA @ 200 ppm recorded significant increases in test weight. Data showed that test weight harvested from the plants sprayed with MH @ 500 ppm and @ 600 ppm showed statistically at par with control (1.01 g and 1.02 g respectively).Whereas, test weight was found significant increase by the spray MH @ 700 ppm and MH @ 800 ppm (1.17 g and 1.24 g respectively) as compared to control.

Table 4.3: Effect of different concentrations of GA_3, NAA and MH on seed yield plant^{-1} (g), seed yield plot^{-1} (g) and test weight (g) of China aster cv. Poornima.

Treatments	Seed yield plant^{-1}(g) ± S.E(m)	Seed yield plot^{1}(g) ± S.E(m)	Test weight (g) ± S.E(m)
T_1(Control)	3.16 ± 0.14	25.74 ± 1.15	0.99 ± 0.01
T_2 (GA_3 100 ppm)	5.44* ± 0.13	45.62* ± 2.08	1.41* ± 0.04
T_3 (GA_3 150 ppm)	5.60* ± 0.12	47.40* ± 1.09	1.43* ± 0.02
T_4(GA_3 200 ppm)	6.38* ± 0.23	55.86* ± 1.41	1.58* ± 0.03
T_5(GA_3 250 ppm)	6.04* ± 0.05	52.42* ± 1.39	1.48* ± 0.02
T_6(NAA 100 PPM)	5.14* ± 0.24	44.76* ± 1.32	1.36* ± 0.02
T_7(NAA 150 ppm)	5.07* ± 0.13	43.82* ± 0.89	1.38* ± 0.01
T_8(NAA 200 ppm)	4.95* ± 0.15	40.48* ± 0.82	1.34* ± 0.01
T_9(NAA 250 ppm)	4.69* ± 0.23	38.46* ± 0.28	1.30* ± 0.01
T_{10}(MH 500 ppm)	3.44 ± 0.25	28.98* ± 1.34	1.01 ± 0.01
T_{11}(MH 600 ppm)	3.73* ± 0.12	30.20* ± 0.42	1.02 ± 0.02
T_{12} (MH 700 ppm)	4.09* ± 0.13	33.97* ± 1.13	1.17* ± 0.02
T_{13} (MH 800 ppm)	4.34* ± 0.23	35.29* ± 1.52	1.24* ± 0.02
S.E(d)	0.18	1.41	0.03
$C.D_{(0.05)}$	0.37	2.92	0.07

***Significant at 5% level of significance with control**

DISCUSSION

CHAPTER 5

DISCUSSION

Growth regulators play significant role in modifying growth and flowering of plants. They change both morphology and physiology of plants. Their effects vary with plant species and varieties, concentration use, frequency of application and various other factors which influence their uptake and translocation in the plant system. Growth regulators are extremely important and valuable in floriculture industry manipulating growth and flowering of many plants. Growth and flowering are usually affected by the environment; however, they are largely influenced by the interaction of internal factors, including endogenous growth substances that control the activity of meristems. Substances that modify plant organs differentially and influence plant form, flowering, yield and quality of the produce are available now. Such substances, are therefore, potentially useful in Floriculture because these when applied at optimum concentrations and at appropriate times will regulate the crops in a beneficial way in terms of growth, flowering, yield and quality.

The findings presented in experimental results gave a detail account of the vegetative, floral and yield attributes, as influenced by plant growth regulators. In this chapter, an attempt has been made to discuss the experimental findings to offer possible explanation for the effect of different treatments with regard to different attributes studied in light of work done by other scientists.

5.1 Effect of different concentrations of GA_3, NAA and MH on vegetative parameters of China aster cv. Poornima

In the present study, results revealed that maximum plant height (85.69 cm) was observed from the plants sprayed with GA_3 @ 200 ppm which was recorded statistically at par with GA_3 @ 150 ppm (82.46 cm). All the applied concentrations of GA_3 recorded significant increase in plant height as compare to control. This might be due to application of GA_3 helps in increasing the level of auxin in tissues and it also enhances the conversion of tryptophan to IAA which causes cell division and cell elongation. This can also be attributed to increased plasticity of cell, promotion of protein synthesis coupled with higher apical dominance. Similar results were reported by Kuraishi and Muir, 1964 in dwarf pea, Padma and Chezhiyan (2003) in chrysanthemum (*Dendranthema grandiflora*), Doddagoudar *et al*. (2004) and Vijaykumar (2017) in China aster. The results also showed that different concentrations of MH applied significantly reduce plant height as compared to control. This might be due to MH act as anti auxin which causes nullification of apical dominance i.e., inhibition of cell division and cell elongation in meristem tissues that finally lead to dwarfing effect on plant growth. Sen and Sen (1968) reported that application of MH causes disturbed carbohydrate and mineral metabolism which causes reduction in plant height. These findings corroborates the results reported by Navale *et al.* (2010) in chrysanthemum, Kumar *et al.* (2012) in rose and Kumar *et al.* (2015) in China aster.

The branches are the skeletal structure of the plant and these were significantly influenced by the application of different plant growth regulators. Maximum numbers of primary branches were found from the plants applied with GA_3 @ 250 ppm and which was found statistically at par with the plants applied with GA_3 @ 200 ppm and MH @ 500 ppm. In case of number of secondary branches per plant maximum was recorded from plants sprayed with GA_3 @ 200 ppm followed by GA_3 @ 250 ppm. The increase in number of branches per plant with application of GA_3 might be due to enhanced cell division and cell enlargement, promotion of protein synthesis coupled with higher dry matter accumulation in the plants. Similar results were reported by Shetty (1995) and Doddagoudar (2002), Nandre *et al*. (2009) and Kumar *et al.* (2015) in China aster. The results revealed that MH also significantly increases the number of primary and secondary branches per plant as compared to control. It might be due to its inhibitory effect on the cell division of the apical bud which subsequently might have retarded the growth of the main axis and this in turn would have accelerated the growth of lateral buds and enhanced the number of branches. These findings are in accordance with reports of Aswath *et al*. (1995) in China aster, Talukdar and Paswan (1998) in chrysanthemum, Bhattacharjee and Singh (1995) in rose hybrids cv. Rakthagandha, Parwal *et al*. (2002) in Damask roses, Prashanth (2003) in Floribunda rose cv. Iceberg, Swaroop *et al*. (2007) in African marigold and Kumar *et al*. (2012) in cut rose cv. First Red.

Plant spread determines the size of the plants in different directions. A well spread plant will look pleasing and artistic as well as produces good number of showy flowers. Maximum plant spread was recorded in plants sprayed with GA_3 @ 200 ppm and minimum plant spread was recorded in the plants grown in control plots. It might be due to production of more number of branches as well as leaves in plants sprayed with GA_3 @ 200 ppm.

Production of leaves leads to the photosynthesis and translocation of photosynthates to other parts of the plants thereby resulting better plant spread. This finding of plant spread was in accordance with the results obtained by Gupta and Dutta (2000), Padama and Chezhiyan (2002), Singhrot *et al.* (2003) and Patel *et al.* (2010) in chrysanthemum.

The maximum number of leaves was found in the plots applied with the GA_3 treatment @ 250 ppm compared to all other treatments and this is due to the increase in plant height and number of branches per plant. Similar results were recorded by earlier research workers Shyamal *et al.* (1990) in aster, Padaganur *et al.* (2005) in tuberose, Rajani (2008) in tuberose and Sethy *et al.* (2016) in ornamental sunflower. Reduction in number of leaves due to Maleic Hydrazide over control in this trial is in contrary with the findings of Shyamal *et al*. (1990) in China aster. The reduction in number of leaves and leaf area by MH treatments over control might be due to reduction in height and its inhibitory and metabolic activity on sub apical meristematic tissues and also due to its antagonist effects on endogenous production of auxins.

5.2 Effect of different concentrations of GA_3, NAA and MH on floral parameters of China aster cv. Poornima

All the treatments differed significantly on the time taken (days) after transplanting for first flower bud initiation and first flower bud opening as well as duration of flowering. Results revealed that GA_3 @ 200 ppm was found to be very effective in inducing earlier bud initiation (57.19 days) and flowering (83.56 days) and duration of flowering (28.11 days) was also noticed maximum in the plants grown in the plots applied with same treatment. Plants sprayed with different concentrations of GA_3 recorded significant earliness in flowering compared to control. It might be due to application of GA_3 causes flower initiation and early flowering by decreasing the concentration of ABA in plant shoot (Phengphachanh *et al*., 2012). Fewer days taken for bud initiation and flower bud opening in China aster in Gibberellic acid treated plants might also be due to the increase in the endogenous gibberellins level in the plant which normally promotes flowering by reducing the juvenile period and the shoot apical meristem instead of producing leaves and branches starts producing buds. The results are in accordance with Joythi and Seemanthini (1997) in chrysanthemum, Katkar *et al.* (2003) in China aster, Padma and Cheziyan (2003) in chrysanthemum, Nandre *et al.* (2009) in China aster, Dalal *et al.* (2009) in chrysanthemum and Patel *et al.* (2010) in chrysanthemum. Maximum days taken to first bud initiation and flowering were recorded in plants applied with NAA @ 250 ppm. The delay in flowering might be attributed to the resultant enhanced apical dominance, which promotes the vegetative phase and ultimately delays flowering. Similar findings were also recorded by Palei (2016) in African marigold.

Results revealed that the flower stalk length was influenced significantly by plant growth regulators. Data presented in Table 4.2(i) indicated that T_3 containing GA_3 @ 150 ppm recorded maximum flower stalk length (39.82 cm) followed by treatments GA_3 @ 200 ppm and GA_3 @ 100 ppm. This might be due to the fact that gibberellic acid promotes cell division and cell elongation resulting in longer stalks. The promotive effect of gibberellins on growth may be due to increasing the auxin level of tissue or enhancing the conversion of tryptophan to IAA which causes cell division and cell elongation (Kuraishi and Muir, 1964). This result was in line with the findings of Chauhan *et al.* (2014) in gerbera and Kumar *et al*. (2012) in rose. The minimum flower stalk length was recorded from the plants grown in plots applied with MH @ 800 ppm. This reduction in the flower stalk length might be occurred as a result of inhibition of cell division and cell elongation due to the growth retarding properties of Maleic Hydrazide. Growth suppression by MH was due to its action as an antiauxin with dwarfing effect on plant growth and nullification of apical dominance (Crafts *et al*., 1950) and also due to disturbed carbohydrate and mineral metabolism (Sen and Sen, 1968).

In China aster, the flower showing higher diameter and weight are preferred in the market. Results revealed that different concentrations GA_3 increased flower diameter and flower weight. The maximum flower diameter (8.80 cm) and flower weight (5.16 g) was also recorded from the plants applied with GA_3 @ 200 ppm. Increase in flower diameter by the application of GA_3 might be the due to its cell elongation effect on plants. The results are in conformity with Talukdar and Paswan (1998) in chrysanthemum, Girwani *et al.* (1990) in African marigold and Sainath *et al*. (2014) annual chrysanthemum. Increase in weight of flower in treated plants might be attributed to the fact that GA_3 promoted the efficacy of plants in terms of photosynthetic activity, uptake of nutrients and their translocation, better partitioning of assimilates into reproductive parts. These results are in agreement with those reported by Singhrot *et al.* (2003) in chrysanthemum and Gopichand *et al.* (2014) in African marigold. Increase in diameter and weight of individual flower due to GA_3 application was reported by Deotale *et al.* (1994), Sharma *et al.* (2001), Kore *et al.* (2003) in China aster, Gautam *et al.* (2006) in chrysanthemum, Swaroop *et al.* (2007) in marigold and Patel *et al.* (2010) chrysanthemum cv. IIHR-6. Flower diameter and average weight were decreased with application of MH treatments over control. The decrease might also be due to inhibitory activity of MH on cell division at the growing tips, as an auxin antagonist. This may be the reason for poor floral development with Maleic Hydrazide. The results are in conformity with the observations of Sen and Naik (1977) in annuals and Reddy and Sulladmath (1983) in China aster. Powell and Andreasen (1957) reported that the quality of individual flowers was distinctly inferior on plants with MH and this was attributed to the non-availability of carbohydrates during the development of flowers.

The number of flowers plant^{-1} and number of flowers plot^{-1} increased in the all the treatments of different plant growth regulators in compared to control. Data presented in Table 4.2(ii) indicated that the maximum number of flowers plant^{-1} (48.76) and number of flowers plot^{-1} (418.56) were recorded with the GA_3 @ 200 ppm over all other treatments. The increase in the number of flowers plant^{-1} as well as plot^{-1} might be due to the increase in the number of primary and secondary branches. Greater dry matter accumulation might be another reason which is certainly suggestive to better photosynthetic activity, other metabolic activities and uptake of nutrients from soil. Therefore, the growth promoting substances might have positive influence on the yield of flowers. The present findings are in conformity with the results of Sunitha (2007) in African marigold, Swaroop *et al*. (2007) in African marigold, Nandre *et al.* (2009) in China aster cv. Poornima, Chopde *et al.* (2015) in gladiolus and Kumar *et al.* (2015) in China aster. The increased number of flowers plant^{-1} and number of flowers plot^{-1} by MH over control might be due to increased number of branches and also removal of apical dominance due to MH which ultimately enhanced the flower production. These results are in conformity with the findings of Aswath *et al*. (1995) in China aster and Khimani *et al*. (1994) in gaillardia, Sharma *et al.* (1995) in chrysanthemum, Dutta and Ramdas (1997) in chrysanthemum, Kumar and Kumar (2004) in Balsam, Kumar *et al.*(2006) in tuberose, Moond and Rakesh (2006) in chrysanthemum and Navale *et al.* (2010) in chrysanthemum.

The results showed that all the treatments containing different plant growth regulators recorded increase in vase life and shelf life of China aster flowers compared to control. Maximum vase life (10.66 days) and shelf life (3.66 days) were recorded in the flowers produced in plants applied with the treatment T_4 containing GA_3 @ 250 ppm. Improvement in vase life of flowers owing to the application of GA_3 might be attributed to the maintenance of higher levels of RNA in leaves thus delaying senescence. The results were in conformity with the findings of Dahale *et al.* (1994) in chrysanthemum, Patel *et al.* (2010) in chrysanthemum and Kumar (2011) in China aster. The increased longevity of flowers with MH might be due to delaying effect of senescence or maturity. Another possibility is that, MH might have regulated the rate of respiration of flowers and thereby increased the longevity of flowers (Nagarjuna *et al*., 1988). The results were in conformity with the findings of Navale *et al.* (2010) in chrysanthemum, Kumar (2011) in China aster and Vaghasia and Polara (2015) in chrysanthemum.

5.3 Effect of different concentrations of GA_3, NAA and MH on seed yield parameters of China aster cv. Poornima

The application of different plant growth regulators on flower yield resulted in marked increase in seed yield plant^{-1}, seed yield plot^{-1} and test weight. The application of GA_3 @ 200 ppm registered significantly maximum seed yield plant^{-1}, seed yield plot^{-1} and test weight whereas minimum seed yield plant^{-1}, seed yield plot^{-1} and test weight was noticed in (T_1) i.e. control. The above results are in conformity with the findings of Swaroop *et al.* (2007) in African marigold, Sunitha (2007) in marigold and Sainath *et al.* (2014) in chrysanthemum. Increase in seed yield plant^{-1} and seed yield plot^{-1} could be attributed to increase in number of primary and secondary branches plant^{-1}, number of flowers plant^{-1} and number of flowers plot^{-1} under this treatment. The increase in test weight might be due to increase in individual seed weight by the application of GA_3.The results are in line with the reports of Shetty (1995) in China aster, Doddagoudar *et al.* (2004) in China aster, Kumar *et al.* (2015) in China aster and Patil *et al.* (2016) in African marigold.

SUMMARY AND CONCLUSION

CHAPTER 6

SUMMARY AND CONCLUSION

The present investigation entitled "Effect of different concentrations of GA_3, NAA and MH on vegetative, floral and yield attributes of China aster [*Callistephus chinensis* (L.) Nees] cv. Poornima" was conducted during March to September 2016 at Floriculture and Landspacing block, College of Horticulture VCSG, UUHF, Bharsar. In this chapter an attempt has been made to summarize results.

1. Among thirteen treatments, maximum plant height (85.69 cm) was observed from the plants sprayed with treatment containing GA_3 @ 200 ppm and minimum plant height (53.38 cm) was recorded from the plants sprayed with MH @ 800 ppm.

2. Plants sprayed with treatment containing GA_3 @ 250 ppm produced maximum number of primary branches per plant and number of leaves (18.36 and 322.76, respectively) which was found statistically at par with GA_3 @ 200 ppm (17.53 and 315.18, respectively)

3. Maximum number of secondary branches per plant (35.83) and plant spread (33.95 cm) were exhibited in plants sprayed with treatment containing GA_3 @ 200 ppm. However, minimum number of secondary branches per plant and plant spread (18.73 and 22.88 cm, respectively) were recorded from the plants grown in control.

4. Various treatments exhibited variable number of days taken to bud initiation and first flower bud opening. It was noticed that plants sprayed with treatment consisting NAA @ 250 ppm took maximum time for initiation of bud as well as flowering (75.23 and 107.39 days, respectively). While, plants sprayed with treatment containing GA_3 @ 200 ppm took minimum days taken to bud initiation and flowering (57.19 and 83.56 days, respectively).

5. Among different treatments applied, maximum duration of flowering (28.11 days) was recorded from the plants sprayed with GA_3 @ 200 ppm.

6. Maximum stalk length (39.82 cm) was recorded in the plants applied with GA_3 @ 200 ppm. Whereas, minimum stalk length (26.19 cm) was recorded in the plants sprayed with MH @ 800 ppm.

7. The maximum flower diameter and flower weight was found from the plants sprayed with GA_3 @ 200 ppm (8.80 cm and 5.16 g, respectively) and minimum flower diameter and flower weight (6.24 cm and 3.38 g, respectively) of plants applied with MH @ 800 ppm.

8. Plants sprayed with GA_3 @ 200 ppm recorded maximum number of flowers plant^{-1} (48.76) and flowers plot^{-1} (418.56).

9. The flowers harvested from plants sprayed with GA_3 @ 250 ppm recorded maximum vase life and shelf life (10.66 and 3.66 days, respectively) and were found statistically at par with plants sprayed with GA_3 @ 200 ppm (10.33 and 3.33 days, respectively). Whereas, plants grown in control plots recorded minimum vase life and shelf life (6.66 and 1.66 days, respectively).

10. The seed yield plant^{-1}, seed yield plot^{-1} and test weight were found maximum from the plants sprayed with GA_3 @ 200 ppm (6.38 g, 55.86 g and 1.58 g, respectively) whereas minimum seed yield plant^{-1}, seed yield plot^{-1} and 1000 seeds weight were recorded in the control plots (3.16 g, 25.74 g and 0.99 g, respectively).

CONCLUSION

Keeping in view it can be concluded that two foliar sprays at 25 and 50 days of GA_3 @ 200 ppm was found more effective in bringing significant improvement in vegetative, floral and yield attributes of China aster cv. Poornima. However, application of MH @ 800 ppm was found effective in reducing plant height.

LITERATURE CITED

CHAPTER 7

LITERATURE CITED

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APPENDICES

APPENDIX I

Statistical analysis for different characters under study

Source of variation	Degree of freedom	Mean sum of squares					
		X1	X2	X3	X4	X5	X6
Replication	2	20.70	0.34	2.48	18.69	1507.95	12.58
Treatment	12	327.15	20.85	95.29	30.42	6311.00	4.14
Error	24	6.62	1.15	1.79	1.56	148.11	4.03

Source of variation	Degree of freedom	Mean sum of squares					
		X7	X8	X9	X10	X11	X12
Replication	2	0.65	14.85	10.54	10.81	0.06	0.03
Treatment	12	119.80	161.02	34.18	64.88	2.42	0.81
Error	24	1.60	2.20	1.72	0.97	0.08	0.03

Source of variation	Degree of freedom	Mean sum of squares						
		X13	X14	X15	X16	X17	X18	X19
Replication	2	8.24	923.63	1.33	0.31	0.65	23.31	0.01
Treatment	12	203.12	16252.95	4.88	0.97	2.94	252.66	0.11
Error	24	10.63	860.47	0.44	0.25	0.05	3.00	0.00

X1=Plant height (cm), **X2**=Number of primary branches plant^{-1}, **X3**=Number of secondary branches plant^{-1}, **X4**=Plant spread (cm), **X5**=Number of leaves plant^{-1}, **X6**= Leaf area (cm^2), **X7**=Days taken to first bud initiation, **X8**=Days taken to first flower bud opening, **X9**=Duration of flowering (days), **X10**=Stalk length (cm), **X11**=Flower diameter (cm), **X12**=Flower weight (g), **X13**=Number of flowers plant^{-1}, **X14**=Number of flowers plot^{-1}, **X15**=Vase life (days), **X16**=Shelf life (days), **X17**=Seed yield plant^{-1}, **X18**=Seed yield plot^{-1} and **X19**=Test weight.

APPENDIX II

Mean monthly meteorological data of VCSG Uttarakhand University of Horticulture and Forestry for the year 2016 (March to August)

Month	Maximum temperature(°C)	Minimum temperature (°C)	Rainfall (mm)
March	12.8	9.1	17.8
April	17.0	13.7	6.0
May	23.5	16.0	47.5
June	28.9	16.7	86.4
July	27.3	16.2	489.2
August	17.8	15.6	242.9

ABSTRACT

ABSTRACT

Name of the student: Aparna Rawat
Year of admission: 2015
Department: Floriculture & Landscape Architecture
Major Field: Floriculture & Landscape Architecture

I.D. Number: 15231
Degree: M.Sc. Horticulture

Minor Field: Soil Science

Thesis Title: "Effect of different concentrations of GA_3, NAA and MH on vegetative, floral and yield attributes of China aster [*Callistephus chinensis* (L.) Nees] cv. Poornima"

The present investigation was conducted to evaluate the vegetative, floral and yield attributes of China aster cv. Poornima in response to different plant growth regulators at Floriculture & Landscaping block, College of Horticulture, Veer Chandra Singh Garhwali Uttarakhand University of Horticulture and Forestry, Bharsar, District Pauri Garhwal (Uttarakhand) from March to September 2016. The experiment was laid out in Randomized Complete Block Design with thirteen treatments. The treatmenSts consisted of control and four concentrations of GA_3, NAA (100, 150, 200 and 250 ppm, each) and MH (500, 600, 700 and 800 ppm). Each treatment consisted of nine plants which were replicated thrice.

The results of investigation revealed that plants sprayed with GA_3 @ 200 ppm produced tallest plant (85.69 cm) with maximum number of secondary branches per plant (35.83) and plant spread (33.95 cm). Flowering attributes *viz.,* minimum days taken to first flower bud initiation and flower bud opening (57.19 and 83.56, respectively) and maximum duration of flowering (28.11 days), stalk length (39.82 cm), flower diameter (8.80 cm), flower weight (5.16 g), number of flowers plant^{-1} (48.76) and number of flowers plot^{-1} (418.56) were recorded from the plants sprayed with GA_3 @ 200 ppm. However, maximum vase life and shelf life (10.66 and 3.66 days, respectively) was recorded from the plants sprayed with GA_3 @ 250 ppm and which was found statistically at par with treatment GA_3 @ 200 ppm. Among the seed parameters, seed yield plant^{-1}(6.38 g), seed yield plot^{-1} (55.86 g) and test weight (1.58 g) were also recorded highest from the plants sprayed with GA_3 @ 200 ppm. The results also revealed that all the applied concentrations of MH significantly reduced plant height as compared to control. Among them, plants sprayed with MH @ 800 ppm recorded minimum plant height (53.38 cm) and maximum vase life (8.33 days), seed yield plant^{-1}(4.34 g), seed yield plot^{-1} (35.29 g) and test weight (1.24 g) as compared to control. However, plant sprayed with MH 500 ppm recorded minimum number of days taken to bud initiation (63.73 days) and maximum duration of flowering (19.45 days), stalk length (27.87 cm) and flower diameter (6.54 cm) as compared to control.

Keeping in view it can be concluded that foliar spray of GA3 @ 200 ppm was found more effective in bringing significant improvement in vegetative, floral and yield attributes of China aster cv. Poornima. However, application of MH @ 800 ppm was found effective in reducing plant height.

Prof. B.P Nautiyal
Chairman

Dr. Mamta Bohra
Advisor

Aparna Rawat
Authoress

सारांश

विद्यार्थी का नाम– अपर्णा रावत
उपाधि– स्नातकोत्तर औद्यानिकी (पुष्पोत्पादन एवं भू–सौन्दर्यीकरण)
विभाग– पुष्पोत्पादन एवं भू–सौन्दर्यीकरण
मुख्य विषय– पुष्पोत्पादन एवं भू–सौन्दर्यीकरण

अभिज्ञान संख्या– 15231
प्रवेश का वर्ष– 2015
सूक्ष्म विषय–मृदा विज्ञान

शोध का विषय–जी.ए.$_3$,एन.ए.ए. एवं एम.एच. की विभिन्न सान्द्रताओं का चाइना एस्टर [*कैलेस्टेफस चाइनेन्सिस* (एल.) नीस] की प्रजाति पूर्णिमा के कायिक, पुष्प एवं उत्पादन विशेषताओं पर प्रभाव।

प्रस्तुत शोध कार्य चाइना एस्टर की प्रजाति पूर्णिमा की कायिक, पुष्प एवं उत्पादन विशेषताओं के विभिन्न पादप वृद्धि नियामकों की प्रतिक्रिया में मूल्यांकन के लिए मार्च से सितम्बर 2016 तक पुष्पोत्पादन एवं भू–सौन्दर्यीकरण प्रखण्ड, औद्यानिकी महाविद्यालय, वीर चन्द्र सिंह गढ़वाली उत्तराखण्ड औद्यानिकी एवं वानिकी विश्वविद्यालय, भरसार, पौड़ी गढ़वाल में आयोजित किया गया। यह शोध कार्य यादृच्छिक पूर्ण प्रखण्ड योजना में तेरह उपचारों में किया गया। उपचारों में नियंत्रण तथा जी.ए.$_3$, एन.ए.ए. (100, 150, 200 एवं 250 पी.पी.एम. प्रत्येक) एवं एम.एच. (500, 600, 700 एवं 800 पी.पी.एम) की चार सान्द्रताएँ सम्मिलित थे। प्रत्येक उपचार में नौ पौधे सम्मिलित थे जो कि तीन पुनरावत्तियों में लगाये गये थे।

शोध के परिणामों से ज्ञात हुआ कि जी.ए.$_3$ @ 200 पी.पी.एम. से उपचारित पौधों में पौध ऊँचाई (85.69 सेमी.) के साथ द्वितीय शाखाओं की संख्या (35.83) एवं पौधे का प्रसार (33.95 सेमी.) अधिकतम पाए गए। पुष्प विशेषताएँ नामतः प्रथम पुष्प कली के प्रारम्भ (57.19 दिन) एवं खुलने के लिए (83.56 दिन) न्यूनतम दिनों की संख्या तथा अधिकतम पुष्पन अवधि (28.11 दिन), डंठल की लम्बाई (39.82 सेमी.), पौधे का व्यास (8.80 सेमी.), पुष्प भार (5.16 ग्रा.), प्रति पौधा पुष्पों की संख्या (48.76), प्रति क्यारी पुष्पों की संख्या (418.56) जी.ए.$_3$ @ 200 पी.पी.एम. से उपचारित पौधों में पाए गए। तथापि अधिकतम पात्र आयु (10.66 दिन) एवं शैल्फ आयु (3.66 दिन) जी.ए.$_3$ @ 250 पी.पी.एम. से उपचारित पौधों में पाए गए जो कि जी.ए.$_3$ @ 200 पी.पी.एम. के समतुल्य पाया गया। बीज मापदंडों में, प्रति पौधा बीजोत्पादन (6.38 ग्रा.), प्रति क्यारी बीजोत्पादन (55.86 ग्रा.) एवं टेस्ट वेट (1.58 ग्रा.) भी जी.ए.$_3$ @ 200 पी.पी.एम. से उपचारित पौधों में अधिकतम पाए गए। परिणामों से यह भी ज्ञात हुआ कि एम.एच. की प्रयोग की गई सभी सान्द्रताएँ नियंत्रण की तुलना में पौधे की ऊँचाई को कम करती हैं। इनमें से एम.एच. @ 800 पी.पी.एम. से उपचारित पौधों में, नियंत्रण की तुलना में न्यूनतम पौध ऊँचाई (53.38 सेमी.) तथा अधिकतम पात्र आयु (8.33 दिन), प्रति पौधा बीजोत्पादन (4.34 ग्रा.), प्रति क्यारी बीजोत्पादन (35.29 ग्रा.), टेस्ट वेट (1.24 ग्रा.) पाए गए। तथापि शोध से यह भी ज्ञात हुआ कि एम.एच. @ 500 पी.पी.एम. से उपचारित पौधों में नियंत्रण की तुलना में प्रथम पुष्प कली के प्रारम्भ के लिए दिनों की संख्या (63.73 दिन) न्यूनतम तथा पुष्पन अवधि (19.45 दिन), डंठल की लम्बाई (27.87 सेमी.) एवं पुष्प व्यास (6.54 सेमी.) अधिकतम पाए गए।

अतः इस शोध से यह निष्कर्ष निकाला जा सकता है कि जी.ए.$_3$ @ 200 पी.पी.एम. सान्द्रता चाइना एस्टर की प्रजाति पूर्णिमा की कायिक, पुष्प एवं उत्पादन विशेषताओं में महत्त्वपूर्ण सुधार लााने में प्रभावी पायी गयी। तथापि एम.एच. @ 800 पी.पी.एम. उपचार पौधे की ऊँचाई घटाने में प्रभावी पाया गया।

प्रो0 बी0 पी0 नौटियाल
अध्यक्ष

डॉ0 ममता बोहरा
सलाहकार

अपर्णा रावत
लेखिका

VITAE

VITAE

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