EFFECT OF GA_3, ALAR, AND BA ON GROWTH, FLOWER YIELD AND VASE LIFE OF CHINA ASTER

(*Callistephus chinensis* (L.) Ness)

काशी हिन्दू विश्वविद्यालय BANARAS HINDU UNIVERSITY

THESIS

Submitted in partial fulfilment of the requirements for the degree of

Master of Science (Agriculture)

In

Horticulture

Supervisor
Prof. S.P. Singh

Submitted by
Ragini Maurya

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Id. No. H-15129 **2017** **Enrolment No. 332714**

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M.Sc.

Ragini Maurya

2017

Affectionately Dedicated to

My beloved parents

For their endless love, support and encouragement

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To,

The Registrar (Academic)
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Through: The Head, Department of Horticulture

Sir,

I have great pleasure in forwarding the thesis entitled **"Effect of GA_3, Alar and BA on growth, flower yield and vase life of China aster (C*allistephus chinensis* (L.) Ness)"** submitted by **Ms. Ragini Maurya** (I.D. No. H-15129) in partial fulfilment of the requirements for the award of the degree of Master of Science (Agriculture) in Horticulture, Institute of Agricultural sciences, Banaras Hindu University, Varanasi.

I certified that the entire work presented in this thesis was planned and carried out by the candidate under my guidance. To the best of my knowledge and belief, the data presented in the thesis are genuine and original. No part of the work has been submitted for any degree or distinction.

Thanking you,   Yours faithfully,

Forwarded   *Dr. S.P. Singh*

(Supervisor)

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BANARAS HINDU UNIVERSITY
VARANASI-221005, UTTAR PRADESH
INDIA

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(RAGINI MAURYA)

Date:

Place: Varanasi.

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LIST OF SYMBOLS AND ABBREVIATIONS

%	per cent
@	at the rate of
°C	Degree centigrade
GA_3	Gibberellic Acid
BA	Benzyl Adenine
CD	Critical difference
cm	Centimeter
cm^2	square centimeter
Contd.	Continued
cv.	Cultivar
DAP	Days after Planting
et al	and others
Fig.	Figure
FYM	Farm yard manure
g	gram
ha	hectare
hrs	hours
i.e.	That is
ppm	parts per million
RBD	Randomized Block Design
SEm	Standard error of treatment means
Wt.	Weight
T	Treatment

INTRODUCTION

Flowers are one of the most beautiful creation of god. Flowers are symbolism of beauty, love, purity and respect. They form the soul of a garden and convey the message of nature to man. The beauty of flower has attracted attention of mankind from beginning of the civilization. In an ancient and religious country like India, flowers are sanctified and are commonly used for worship in temples. We are intimately associated with flowers, and all on festive occasions, in marriages, religious ceremonies and social functions, the use of flowers and garland have become almost essential. The flowers also adorn the hair of women, particularly in South India.

According to Agricultural and Processed Food Products Export Development Authority (APEDA) 2014-15, the total area under flower crops in 2014-15 was 248.51 thousand hectares. Total area under floriculture in India is second largest in the world and only next to China. Production of flower was estimated to be 1685 thousand tonnes of loose flowers and 472 thousand tonnes of cut flower in 2014-15. Fresh and dried cut flower dominate floriculture exports from India. Among states, Karnataka is the leader in floriculture with about 29,700 hectares under floriculture cultivation. Apart from this other major flower growing states are Tamil Nadu and Andhra Pradesh in the South, West Bengal in the East, Maharashtra in the West and Rajasthan, Delhi and Haryana in the North.

Annuals are those plants which complete their life cycle in one season or one year. These are genetically programmed to produce seed and die in one season or year , all food and energy of annual go to flower and seed production .There are different types of annuals like winter, summer and rainy annuals. China aster, *Callistephus chinensis* (L.) Ness belongs to one of the largest families of flowering plants, ‘Asteraceae’. Its chromosome number is 18.

Callistephus chinensis is native to China and has spread to Europe and other tropical countries during 1731 A.D. Aster 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*. *Callistephus* is a monotypic (unispecific) genus of flowering plants in the aster family, Asteraceae, containing the single species. The name of the genus '*Callistephus*' is derived from two Greek words 'Kalistos' meaning 'most beautiful' and Stephos ' a crown', referring to the flower head. China aster is a very popular winter annual flower crop and is mainly cultivated for production of cut flowers, loose flowers, as pot plant and for bedding plant purposes in landscape. It is gaining fast popularity in India because of its easy cultural practices, diversity of colours and varied uses. There is a vast scope of growing China aster in Himachal Pradesh throughout the year except in severe winters and scorching summer months for the purpose of cut flowers and loose flower production. Since there is scanty information on the effect of cultivars and date of planting on China aster particularly in North Indian conditions hence need was felt to standardize the suitable planting time for cultivation of its varieties in the mid hill conditions of Himachal Pradesh for the commercialization of this crop owing to the reason that planting time and varieties play a vital role in obtaining the better growth and flowering. 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 the shape of ray florets. Its height varies from 20 cm to 1 m tall depending upon the genotype. The flower heads, up to 12 cm across, are often totally composed of petal like ray flowers.

The present day varieties are available in diverse forms, types and a wide spectrum of colour ranges from white and pale yellow to pink, rose, red, blue, purple, and violet. 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 and worldwide as an ornamental plant. The exact area of cultivation and crop production in India is not available. However, it is estimated that, it is grown in about 3500 ha area is in India (Kalavalli *et al*., 1991). During 1996-97, the cultivation of China aster has accounted for 4.78 percent of the total area of commercial flower crops and 9.16 per cent of total yield of flower production in Karnataka alone.

In the northern plains, late flowering types of China aster are sown during August -September. In India, September-October is ideal time for sowing annuals. Asters can be grown successfully in open conditions. The seeds are first raised in the seed bed and then seedling are planted for flowering and seed production. Flowers are produced after about 2.5-3 month of sowing. It is a popular bedding plant and is also used as an herbaceous border. Dwarf types are highly suitable for edging and window boxes. Long stalk flowers are used in vases, preparation of bouquets while loose flowers are used in garland making.

Increase in flower production both qualitatively and quantitatively and reduction in the plant forms are the important objectives to be reckoned in commercial flower cultivation. As tall plant lodge easily resulting in reduced flower size and yield per plant. Though the quantity and quality of flowers is primarily a genetical trait, it is greatly influenced by environmental, nutritional and other management factors also.

Although environment and genetic factors greatly affect the yield and quality, exogenous application of growth regulators plays a major role on growth i.e.; plant height, number of branches, yield and quality parameters of China aster (Sheela, 2008).

Recently, plant growth substances have been used as an effective tool to improve vegetative as well as reproductive function of plant. Plant growth regulators or phytohormones are organic substances produced naturally or synthetically in higher plants, controlling growth or other physiological functions at a site remote from its place of production and active in minute amounts. Plant growth regulators include growth promoter and growth inhibitors. The major growth regulators are auxin, gibberellin, cytokinin, abscisic acid and ethylene. Exogenous application of plant growth regulators in fact has revolutionized, agriculture, more particularly horticulture in developed countries. Application of plant growth regulators are playing a leading role in production and post-harvest handling of cut flowers. Growth regulators application 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. Within the broad group of plant growth regulators, some act as growth promoters, while others act as growth retardants and inhibitors. The plant growth regulators have been used in floriculture to manipulate plant growth in a desired direction (Sharma *et al*., 2001). Among plant growth substances, gibberellins and benzyl adenine (BA) are used to promote growth of plants while alar is inhibits the growth of plant.

Gibberellin was discovered by a Japanese scientist Kurosawa found that the rice seedlings infected by the fungus *Gibberella fujikuroi* grow taller and turned very thin and pale. An active substance was isolated from the infected seedlings and named as Gibberellin. Biosynthesis of gibberellins in plants, the primary precursor for the formation of gibberellins is acetate.

Acetate + COA → Acetyl COA → Mevalonic acid → MA pyrophosphate → Isopentanyl pyrophosphate → Geranyl pyrophosphate → GGPP → Kaurene → Gibberellins.

Major role of gibberellin is to promote seed germination, breaking dormancy of buds, root growth, elongation of internodes, bolting and flowering, gibberellins are found in all parts of higher plants including shoots, roots, leaves, flower, petals, anthers and seeds. In general, reproductive parts contain much higher concentrations of gibberellins than the negative parts. Immature seeds are especially rich in gibberellins.

Kinetin was discovered by Skoog and Miller (1950) from the tobacco pith callus and the chemical substance was identified as 6-furfuryl aminopurine. Because of its specific effect on cytokinesis (cell division), it was called as cytokinins or kinetin/BA (Benzyl Adenine). The term, cytokinin was proposed by Letham (1963). Fairley and Kingour (1966) used the term, phytokinins for cytokinins because of their plant origin. Chemically cytokinins are kinins and they are purine derivatives. Cytokinins, besides their main effect on cell division, also regulate growth and hence they are considered as natural plant growth hormones. Some of the very important and commonly known naturally occurring cytokinins are Coconut milk factor and Zeatin. It was also identified that cytokinin as a constituent of t-RNA. It is assumed that cytokinins are synthesized as in the case of purines in plants (nucleic acid synthesis). Root tip is an important site of its synthesis. However, developing seeds and cambial tissues are also the site of cytokinin biosynthesis. Kende (1965) reported that cytokinins move upwards perhaps in the xylem stream. However, basipetal movement in petiole and isolated stems are also observed. Seth *et al*., (1966) found that auxin enhances kinetin movement (translocation) in bean stems.

Major role of cytokinin is cell division, cell enlargement, promotes the growth of lateral buds, delay of senescence, flower induction, morphogenesis, and protein synthesis.

Although a general retardation of plant growth may often be desirable, yet maintenance of certain level of growth may sometimes, be necessary. Much elongated plants are spindly and unattractive (an important considerable with ornamentals). Plant growth retardants can control the amount of vegetative growth and play an important role in floriculture. Growth retardants retard sub-apical meristematic activity which is responsible for stem elongation. Alar (Daminozide) is a plant growth inhibitor Chemical Name: Butanedioic acid (mono 2, 2-dimethylhydrazine), Succinic acid (2, 2 dimethyl hydrazide).Trade Names is Alar, Kylar, SADH, B-nine, B-995, aminozide, Alar inhibits shoot growth and often enhances floral initiation. Foliar application of Alar promotes flowering. It can also effectively delay flowering and increased the number of flower per plant and size of flower. It is most effective in cooler climates.

In view of these consideration the present research work entitled "Effect of GA_3, Alar and BA on the vegetative growth, flower yield and vase life of China aster (C*allistephus chinensis* (L.) Ness)" was under taken at Horticultural field, Institute of Agricultural Science, Banaras Hindu University in 2016-2017 with the following objectives.

1. To study the effect of GA_3 on growth, flower yield and vase life of China aster.
2. To study the effect of Alar on growth, flower yield and vase life of China aster.
3. To study the effect of BA on growth, flower yield and vase life of China aster.
4. To assess the optimum concentration of GA_3, Alar and BA on growth, flower yield and vase life of China aster.

REVIEW OF LITERATURE

China aster is one of the commercially important cut flower ranking next to chrysanthemum and marigold. China aster cultivation is highly remunerative and has good export potential. Use of plant growth substances constitutes as one of the most important horticultural tools to manipulate the plant growth in a desired direction. Many scientists have investigated the influence of plant growth regulators on various growth and flowering aspects in flower crops.

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. Among plant growth substances, gibberellins and benzyl adenine (kinetin) are used to promote growth of plants (promoting cell elongation and cell division) while alar inhibits the growth of plant. Growth retardants retard sub-apical meristematic activity which is responsible for stem elongation.

2. Effect of plant growth promoters and retardants on growth and flowering yield in China aster:

2.1. Effect of different concentrations of Gibberellic acid on growth character

Reddy and Sulladmath (1983) in their studies on China aster in winter season reported that plant height increased with increasing concentrations of GA_3 from 100 ppm to 300 ppm (47.72 cm to 62.55 cm) respectively.

GA at 200 ppm exhibited significant effect on plant growth and recorded maximum (62.73 cm) plant height in Chrysanthemum (Nagarjuna *et al*., 1988)

Girwani *et al*., (1990) revealed that GA_3 at 100 ppm effectively induced maximum (122.77 cm) plant height with less number of branches per plant in African marigold cv. African Giant similarly, Dahale *et al*. (1994) reported that GA_3 at 100 ppm on cultivar Gomati recorded maximum plant height (88.5 cm) with maximum no of branches (29). Similar results were also reported by Gautam *et al*. (2006) with using GA_3 at 200 ppm in *Chrysanthemum morifolium* cv. Nilima.

Ramesh *et al*. (2001) noted the effect of plant growth regulators on growth and yield of China aster cv. Kamini that GA_3 treatment at 60 days of planting exhibited increase in plant height over control, however GA_3 at 150 ppm recorded highest plant height (75.10 cm).

Sujata *et al*. (2002) concluded that foliar application of 100 ppm GA_3 at monthly intervals from January to May was best treatment for obtaining best growth of plants in Gerbera.

Tyagi and Kumar (2006) revealed that maximum plant height (22.25 cm), plant spread (25.88 cm), stem diameter (1.03 cm), number of primary branches per plant (15.49) were recorded when the plants were sprayed with GA_3 @ 200ppm African marigold *(Tagetes erecta* Linn.).

Kishan Swaroop *et al*. (2007) reported that foliar spray of GA_3 at 300 ppm recorded maximum plant height (89.50 cm) and maximum number of primary branches per plant (8.75) compared to other treatments in African marigold.

Baskaran and Misra (2007) noted earliness in corm sprouting was observed by GA_3 at 500 ppm as corm dipping followed by GA_3 at 1,000 ppm in Gladiolus.

Sunitha *et al*. (2007) revealed that GA_3 at 200 ppm recorded maximum plant height (101.2 cm) and more number of branches per plant (14.50) compared with other plant growth regulators in African marigold.

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

Dalal *et al.* (2009) revealed that foliar application of GA_3 at 200 ppm concentration resulted in maximum plant height in chrysanthemum under net house conditions.

Nandre *et al*. (2009) reported that GA_3 at 100 ppm exhibited significant recorded less no of days taken to first flower bud initiation (64.33) than 200 ppm (67.67) and GA_3 at 200 ppm recorded maximum flower yield per plant (110.20 g) in China aster.

Himabindu (2010) reported that maximum inter nodal length with GA_3 at 300 ppm in African marigold cv. Pusa Narangi Gainda.

Ghadage *et al.* (2010) found that maximum height of plant, maximum number of leaves obtained in treatments GA_3 200 ppm in Gaillardia.

Dogra *et al.* (2012) found that maximum plant height, number of leaves and leaf width was recorded at 300 ppm GA_3 in Gladiolus.

Girisha *et al*. (2012) noted that spraying of GA_3 at 150 ppm resulted in maximum plant height (30.75 cm), leaf length (14.77 cm), leaf width (2.54 cm), leaf area (1008.80 m2) and higher chlorophyll contents in leaves (1.13 mg/g) than control (0.45 mg/g) in daisy (*Aster amellus* L.) cultivar Dwarf pink.

Kumar *et al.* (2012) reported that Gibberellic acid at higher concentration of 100ppm as a preharvest spray exerted a significant influence on crop growth and recorded highest mean values for plant height (76.18cm), stalk length (60.98cm), stem girth (1.66cm) and total chlorophyll content (1.826mg/g) in cut roses.

Neetu *et al.* (2013) recorded that maximum number of leaves/plant in cv. Gunjan at 200 ppm GA_3 in Gladiolus.

Sharma and Joshi (2015) found that foliar application treatments, GA_3 @ 250 ppm foliar spray significantly increased plant height, leaf area per plant and number of leaves per plant China aster.

Shivasankar and Manivannan (2015) reported that superior in improving the sprouting percentage of tubers and other growth characters like plant height, number of branches and number of leaves at 250 ppm GA_3 in Glory lily (*Gloriosa superba* L.)

Syiemlieh *et al*. (2016) concluded that application of GA_3 @ 300 ppm superior on plant height(23.00cm), plant spread(48.63cm), number of branches (13.30), number of leaves (570.50) in Petunia.

2.2. Effect of different concentrations of Gibberellic acid on flowering character

Reddy and Sulladmath (1983) reported that GA_3 at 200 ppm recorded maximum number of flowers per plant (40.53) compared to other treatments and highest yield per plant (66.70 g) and yield per ha (3.33 tonnes) in China aster cv. Vick's Branching Purple.

Nagarjuna *et al*. (1988) observed that foliar spray of GA_3 at 200 ppm produced large sized flowers (5.99 cm in diameter) and maximum weight of flowers (113.33 g) per plant compared to other treatments in *Chrysanthemum indicum*.

Girwani *et al*. (1990) reported that GA_3 at 100 ppm induced maximum flower diameter (5.78 cm) and minimum flower diameter was with control (5.00 cm) in African marigold cv. African Giant.

Dahale *et al*. (1994) reported that GA_3 at 100 ppm significantly increased the average yield of flowers per plant (202.7 g) in Chrysanthemum.

Ramesh and Selvarajan Chezhiyan (2001) reported that GA_3 at 100 ppm recorded significant reduction in time taken for 50 and 100 percent flowering over control in China aster cv. Karina.

Sharma *et al.* (2001) studied the effect of GA_3 at 50 ppm on four cultivars of Chrysanthemum and recorded that GA_3 at 50 ppm promoted early appearance of flower buds in cvs. Snow ball, Kikubiori and Premier.

Padma priya and Chezhiyan (2002) studied the effect of GA_3 on four cultivars of Chrysanthemum (*Dendranthema grandiflora* tzelvev) and revealed that GA_3 significantly advanced the flowering from bud initiation (57.63) as compared to other treatments.

Sujatha *et al*. (2002) concluded that foliar application of 100 ppm GA_3 at monthly intervals from January to May was best treatment for obtaining best growth of plants, maximum number of cut blooms with stalk length as well as flower size in Gerbera.

Kore *et al*. (2003) reported that foliar spray of GA_3 at 200 ppm recorded highest flower yield (89.44 quintals per ha) in China aster cv. Ostrich Plume Mixed.

Singh (2004) reported that GA_3 at 200 ppm increased number of seeds/flower and effect of GA_3 @ 100 ppm was noticed on increasing seed weight/ flower and weight of 100 seeds in marigold.

Verma and Arha (2004) observed that maximum number of flowers per plant (36.25) and flower yield per plant (82.62 g) and flower yield per ha (9617.48 kg) were highest with GA_3 at 200 ppm compared to other treatments in African marigold.

Gautam *et al*. (2006) reported that GA_3 at 200 ppm recorded maximum number of flowers per plant (44.94), the highest weight of flowers per plant (128.11 g) and the highest flower yield (14.23 tons per ha) than control in *Chrysanthemum morifolium* cv. Nilima.

Tyagi and Kumar (2006)reported that number of flowers per plant (14.00), flower diameter (5.62 cm), stalk length (2.47 cm), fresh weight per flower (6.17 g), weight of flowers per plant (86.31 g) and yield of flowers per hectare(71.92 q) were recorded when the plants were sprayed with GA_3 200 ppm.in marigold.

Sunitha *et al.* (2007) reported that foliar application of GA_3 at 200 ppm increased the number of flowers (68.7) over other treatments in African marigold.

Kishan Swaroop *et al*. (2007) reported that the maximum number of flowers per plant (23.75), maximum fresh weight of single flower (6.92 g) and recorded higher flower yield per plant (433.00 g) compared to other treatments with GA_3 at 300 ppm African marigold cv. Pusa Narangi Gainda.

Patel *et al*. (2010) reported that GA_3 150 ppm gave significantly maximum flower diameter (8.76 cm), lower ((116 days) number of days to 50 per cent flowering (5.93 g) and maximum flower yield over control in *Chrysanthemum morifolium* ramat cv. IIHR-6.

Reddy *et al*. (2014) reported that higher mean spike length (137.98 cm) and number of florets per spike (14.06) were recorded with GA_3 at 100 ppm in gladiolus cv. White prosperity.

Dogra *et al*. (2012) observed that spike length, rachis length, corm diameter, corm weight and early flowering was recorded at 300 ppm GA_3 in Gladiolus.

Girisha *et al*. (2012) reported that GA_3 at 150 ppm early flowering i e, days to first flowering and days to 50 per cent flowering (56.30 and 60.42 days, respectively), spike length (28.88 cm) and rachis length (26.53 cm). GA_3 at 100 ppm recorded more flower size (3.37 cm) in Daisy (Aster amellus L.) cv. Dwarf Pink.

Kumar *et al*. (2012) observed that mean flower diameter (6.89cm), anthocyanin content (0.1970 OD value) and vase life (2.6 days). Likewise the earliest flowering (40.00 days) was also obtained from preharvest spray of gibberellic acid at 100 ppm in cut roses.

Neetu *et al*. (2013) reported that early spike emergence and colour show were noticed with cv. Sabnum when GA_3 was sprayed at higher concentration (300-400 ppm) and higher size of first and fifth floret was recorded with cv. J.V. Gold at 200-300 ppm GA_3. GA_3 at 300 ppm also exerted maximum length of spike, whereas maximum number of florets/spike was recorded with cv. Snow Princess when GA_3 applied at 100-200 ppm in Gladiolus.

Munikrishnappa and Chandrashekar (2014) observed that Spraying of GA_3 at 200 ppm enhanced the duration of flowering (90.33), number of flowers per plant (68.54), diameter (4.86 cm), flower weight (3.26 g), flower yield per plant (111.2 g) and vase life (22.88 days) in China aster.

Kumar *et al.* (2015) observed that GA_3 300 ppm perform early flower bud initiation (48 days), opening of first flower (89.87 days), duration of flowering (50.47 days), flower stalk length (8.95 cm), flowers/plant (60.33), closely followed by GA_3 200 ppm over other growth regulators in marigold.

Syiemlieh *et al*. (2016) reported that GA_3 @100 ppm was found to be superior on number of flowers per plant (54.47), yield of flowers per plant(126.63 g), yield of flowers per plot (1115.33 g) and yield of flowers per hectare (7.56 t) was observed as compared with control in Petunia.

2.3. Effect of alar on growth parameters

Suparna *et al*. (1993) observed that maximum increase in leaf area, fresh weight and dry weight of stems were recorded by alar at 4000 ppm in *Gloriosa superba.*

Khimani *et al*. (1994) reported that increased leaf number, dry weight and leaf area have been found with alar at 1500 ppm in Gaillardia.

Mitali and Talukdar (1997) observed that maximum reduction in the height of pinched and unpinched plants were observed with alar at 10000 ppm in chrysanthemum.

Yassin *et al*. (2013) reported that the maximum number of main branches was obtained from the combination of 2g/L Alar in Verbena (*Verbena X hybrida*).

Asrar *et al*. (2014) observed that Alar at 1500 ppm significantly increased the number of branches, number of leaves, leaf area and relative chlorophyll content in Chrysanthemum.

Kumar *et al*. (2015) noted that Alar 1500 mg/L reducing plant height and increasing number of branching in China aster.

2.4. Effect of alar on flower characters

Beura and Maharana (1990) reported that lowest shoot to root ratio and the highest number of tubers/plant, height tuber length, diameter and tuber yield with 2500 ppm alar in dahlia.

Khimani *et al*. (1994) reported that highest flower number and yield was recorded by 500 ppm alar in gaillardia.

Singh *et al.* (1994) reported that application of alar at 100 ppm found to produce dwarf plants, largest leaf number, widest stem diameter, largest number of branches per plant, and more number of flowers per plant, longer flowering period and highest seed weight per plant over control in dahlia.

Aswath *et al*. (1995) reported that increased vase life by 2.6 days has been found with alar at 500 ppm in China aster.

Mitali and Talukdar (1997) reported that application of alar at 10,000 ppm resulted in greatest reduction in number of days to full bloom, increase in number of flowers per plant compared to control in both pinched and unpinched chrysanthemum.

Reddy *et al*. (1999) reported that application of alar at 2000 ppm resulted in increase in thickness of leaves, number of layers in palisade tissue, number of chloroplast and starch grains in spongy cells in China aster.

Arora *et al*. (2002) observed that plants sprayed with alar at 1000 and 1500 ppm were the earliest to flower in 102.16 and 102.65 days over control (112.78 days) in chrysanthemum.

Atanassova *et al*. (2004) reported that plant growth regulators (PGRs) on flowering and some quality parameters of mini carnation (*Dianthus caryophyllus* f. *spray*) cut flower was studied in a greenhouse. Plants of Bulgarian cultivars Yanita, Naslada and Russalka were treated 3 times with water solutions of Alar [daminozide] (N,N'dimethyl hydrazide of succinic acid) at 500 and 1000 mg/L. Alar stimulated the beginning of flowering and full flowering.

Asrar *et al*. (2014) observed that Alar at 1500 ppm increasing inflorescence diameter and the number of inflorescences in chrysanthemum.

Kumar *et al*. (2015) noted that Alar 1500 mg/L increasing 50% flowering in China aster.

2.5. Effect of different concentrations of BA on plant growth and flowering

Mutui *et al*. (2001) reported that 50 mg/liter BA equivalent consistently increased the number of days to full opening of primary florets and delayed the onset of flower senescence as measured by days to 50 % petal fall and days to 50 % leaf yellowing and 100 mg/L BA equivalent reduced significantly the leaf water content of Alstroemeria (*Alstroemeria aurantiaca l.*) cut flowers.

Sooch *et al*. (2002) reported that the combined application of NAA and kinetin each at 100 ppm significantly increased the number of branches per plant and increased in flower size significantly in Carnation.

Baskaran and Misra (2007) observed that BA at 100 ppm as corm dipping treatment gave the maximum number of shoots per Corm and spraying treatment gave minimum spike length and rachis length in gladiolus.

MATERIALS AND METHODS

A field experiment entitled "Effect of GA_3, Alar and BA on growth, flower yield and vase life of China aster (C*allistephus chinensis* (L.) Ness)" was conducted at Horticultural Garden of the Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi during the year 2016-2017. The details of existing agro climatic conditions, experimental procedures employed during experimentation are briefly described in this chapter.

LOCATION OF THE EXPERIMENTAL SITE

The experiment was carried out at the, Horticultural Garden of the Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. This location is situated in South-Eastern part of Varanasi city at 25° 15' North latitude and 83° 03' East longitude at an elevation of 129.23 m above the mean sea level and it is located in the center of Indo Gangetic plains.

CLIMATIC CONDITION

Varanasi has a tropical and sub-tropical climate situated in the eastern part of U.P. and lies in the center of north alluvial plain on the left side of river the Ganges with large variation in summer and winter temperature *i.e.*, extreme of hot weather in summer and cold in winter.

On the basis of available knowledge, the climatic conditions of this area for an entire year are divided into three parts:-

1. Summer season : Beginning of March to third week of June
2. Rainy season : Last week of June to October
3. Winter season : November to February

Table 2.1: WEEKLY METEOROLOGICAL DATA: VARANASI, YEAR-2016-17

Week No.	Month & Date	Rainfall mm	Temperature ^0C		R.H. %		Wind Speed km/hr	Sunshine hours	Evaporation (mm)
			MAX	MIN	Morn	Even			
43	21-27	0.0	32.4	17.9	74	43	1.2	7.7	2.8
44	28-03	0.0	31.4	16.6	77	43	0.2	8.0	2.2
45	Nov 04-10	0.0	29.2	15.3	80	45	1.1	3.9	2.1
46	11-17	0.0	29.0	13.8	77	42	0.3	6.6	2.1
47	18-24	0.0	27.3	11.7	72	42	1.8	4.7	1.7
48	25-01	0.0	25.4	13.2	79	56	2.0	3.7	1.8
49	Dec 02-08	0.0	20.3	16.3	94	78	1.0	0.2	0.8
50	09-15	0.0	20.2	10.0	94	73	0.8	1.2	0.7
51	16-22	0.0	23.3	9.8	89	50	2.4	3.2	1.8
52	23-31	0.0	20.5	10.9	94	69	1.4	0.2	0.9
1	Jan 1-7	0.0	24.3	9.6	94	47	4.2	2.5	1.2
2	8-14	0.0	25.0	10.7	85	45	1.9	5.9	1.7
3	15-21	7.7	19.0	11.0	94	69	1.9	0.6	0.9
4	22-28	0.0	21.7	7.2	85	43	2.0	5.2	1.6
5	29-04	0.0	24.7	11.9	79	50	2.0	6.5	2.1
6	Feb 05-11	0.0	24.5	9.6	83	52	2.3	6.3	2.2
7	12-18	2.4	27.1	13.5	85	57	1.7	6.3	2.2
8	19-25	0.0	28.6	14.9	77	44	4.0	8.5	3.6
9	26-03	0.0	29.9	16.2	85	51	1.4	6.4	2.7
10	March 04-10	19.2	30.9	17.9	77	46	2.4	7.6	3.3

The average annual rainfall is about 1110 mm. The major portion of precipitation about 85 to 90% is received during July to September. In July precipitation reaches at its peak with average of 299 mm. With an average temperature of 34.3^{0}C, May is the hottest month of the year. At 16.5^{0}C on average, January is the coldest month of the year.

DETAILS OF THE EXPERIMENT

Variety

The variety selected for the present experiment was Local. The duration required for the first flowering is more than 65-70 days after planting. The number of laterals produced per plant is quite less. The open flower on the plant has moderate life.

Experimental Design

The experiment was laid out in Randomized Block Design with four replications. The treatment were allocated randomly in each plot using Fisher and Yates allocation random table (Panse and Sukhatme, 1985). There were seven treatments and each was applied separately to the plant at different successive staged of growth. The details of treatments are given below with their symbols.

Table 3.2: Treatment details

T_0	Control (Water sprayed)
T_1	75 ppm GA_3
T_2	150 ppm GA_3
T_3	300 ppm Alar
T_4	600 ppm Alar
T_5	20 ppm BA
T_6	40 ppm BA

Table 3.3: Details of Experimental Unit and layout:

Design of experiment	R.B.D
Number of treatments	7
Number of replications	4
Total number of plots	28
Length of experimental field	15.6 m
Width of experimental field	4.5 m
Width of sub- irrigation channel	0.4 m
Net plot size	1x1.3 m
Gross area of experimental field	70.2 m
Net area under experiment	1.3 x 21 = 27.3 m^2

Preparation of field

The experimental soils were prepared by digging the experimental plot twice. The soils were made clean friable for planting the seeding by digging removing the weeds and breaking the clods. The total area under experiment was divided into different blocks according to the layout of the experiment.

Transplanting

Thirty days old healthy seedlings were ready for transplantation in the main field .The seedlings of China aster having the height of 5-6 cm were taken from Horticultural garden, Banaras Hindu University and were transplanted in well prepared plots of 27.3 m^2 at the distance of 30x20 cm in the evening of 20^{th} November 2016.

Fertilizer application

Prior to transplanting of seedling the soil of the experimental area was enriched by application of adequate amount of nitrogen, phosphorus and potash. The full amount of phosphorus and potash along with half amount of nitrogen was applied at the time of transplanting. The balance amount of nitrogen was applied as top dressing at the flowering time. The nitrogen was applied in form of urea while phosphorus and potash were given as single super phosphate (SSP) and muriate of potash (MOP).

Irrigation

Immediately after transplanting the seedlings were irrigated. Water was supplied to the seedlings through rubber pipe from the source so that light watering of seedlings could be done. Irrigation was performed at fortnightly interval keeping in mind the weather conditions.

Hoeing and weeding

Hoeing and weeding were also performed in order to keep the field free from weed and allow the healthy growth of plants. Three hoeing and weeding were performed during the life span of crop.

PREPARATION OF SOLUTIONS

Gibberellic acid (GA_3)

Solutions of GA_3 75 and 150 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. The prepared solutions were sprayed uniformly over the treatments immediately after preparation at 30 days after transplanting.

Alar (B-nine)

The solutions of Alar 300 and 600 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. The prepared solutions were sprayed uniformly over the treatments immediately after preparation 30 days after transplanting.

BA (Benzyl adenine)

Solutions of BA 20 and 40 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. The prepared solutions were sprayed uniformly over the treatments immediately after preparation 30 days after transplanting.

Application of treatment

There were seven treatments of GA_3, Alar and BA each in two levels along with control (control plot were sprayed with top water) containing teepol as surfactant. The solution was sprayed in the early hours of day when the dew become evaporated. The spraying was done with the help of hand atomizer in such way as both the surface of leaf became well wetted. The sprayer was thoroughly washed after each spray to avoid the contamination. The spray was done at 30 days after transplanting.

Sampling technique

The samples were collected randomly from each plot. Five randomly selected plants were considered as a unit for a replication. The randomly selected plants were tagged for recording desired observations.

Recording of observation

Observation of growth, flowering and vase life were noted at regular interval throughout the experimentation to judge the significance of the various treatments.

A. Observation of Growth Characters

The effect of different treatments on vegetative growth was studied weekly by recording the observation at 30^{th} days after transplanting. The following parameters were studied under growth characters.

1. Height of plant
2. Leaf length
3. Leaf width
4. Leaf area
5. Number of branches per plant

Height of Plant (cm)

Height of the tagged plants was measured in centimeters from ground level to the growing tip (terminal bud) with the help of meter scale.

Leaf length (cm)

Leaf length was taken in centimetre between leaf base to leaf apex.

Leaf width (cm)

Leaf width was taken in centimetre.

Leaf area (cm^2)

Leaf area was determined for all the leaves of the selected plants with the help of an electronic leaf area meter model LI-3100, Lincoln, Nebraska, USA and expressed in square centimetres.

Number of branches per plant

The number of branches per plant were counted at flowering time. The lateral shoots emerged from the main stem were treated as branches.

B. Observation of flowering characters

Flowering characters regarding the flowering of China aster were recorded at periodical intervals from five randomly selected plants in each plot.

Number of days to first flower

The number of days taken for the commencement of opening of the peripheral ray florets was counted from the date of planting.

Number of flowers per plant

The total number of healthy flowers per plant were counted in tagged plants and averages were worked out and presented as total number of flowers per plant.

Flower diameter (cm)

The maximum breadth across the head of the flowers were recorded as flower diameter and was measured in centimeter by using Vernier Calipers.

Fresh weight and Dry weight of flower

There are taking the fresh weight and dry weight (oven dried) of tagged plant's flower with help of weighing machine in g.

Flower yield per plant (g)

There are taking total weight of healthy flowers was recorded for five tagged plants and their mean values were worked out and presented as total number of flowers per plant.

Flower yield per plot (g)

Flower yield per plot was computed on the basis of pooled fresh weight of flowers plucked from plants of the plot at different times and expressed in grams.

Flower yield (t/ha)

Flower yield per hectare was computed on the basis of pooled fresh weight of flowers plucked from each net plot at different times and the yield of observational plants was also added to the net plot yields for the purpose of computing plot and hectare yields and expressed in kg and tonnes respectively.

Vase life in distilled water (days)

Number of days was recorded till the complete wilting of flowers after placing the flowered stalks in distilled water.

STATISTICAL ANALYSIS

In order to examine the significance of differences occurring from treatment to treatment, days of observations and their interaction effects were subjected to statistical analysis by method of Panse and Sukhatme (1985) and with the help of Fisher and Yates (1968). Table of critical differences was calculated at 5% and 1% level of significance. The differences between significant treatments means were tested against critical differences at (P =0.05) percent where F variance showed significant differences.

'F' Value – It was calculated for replication and treatment both by following formula.

$$F = \frac{\text{M.S.S for treatment or replication}}{\text{M.S.S for error}}$$

Where M.S.S. – Mean sum of square

Critical difference

$$C.D = t \times \sqrt{2 \text{ error M.S.} / N}$$

Where, t = tabulated value at 5% and 1% level at error degree of freedom

N = number of plots

Economics of treatments

The economics of various treatments in order to evaluate their viability in giving rise net profit per hectare over control in China aster crop was determined. The cost of production owing to a particular treatment and its returns from the produce were worked out.

Cost of cultivation (Rs. /ha)

The cost of the inputs prevailing at the time of cultivation of China aster taken into account to work out the cost of cultivation of this crop.

Gross income (Total income)

Gross income was calculated on the basis of prevailing market price for the produce.

Net income

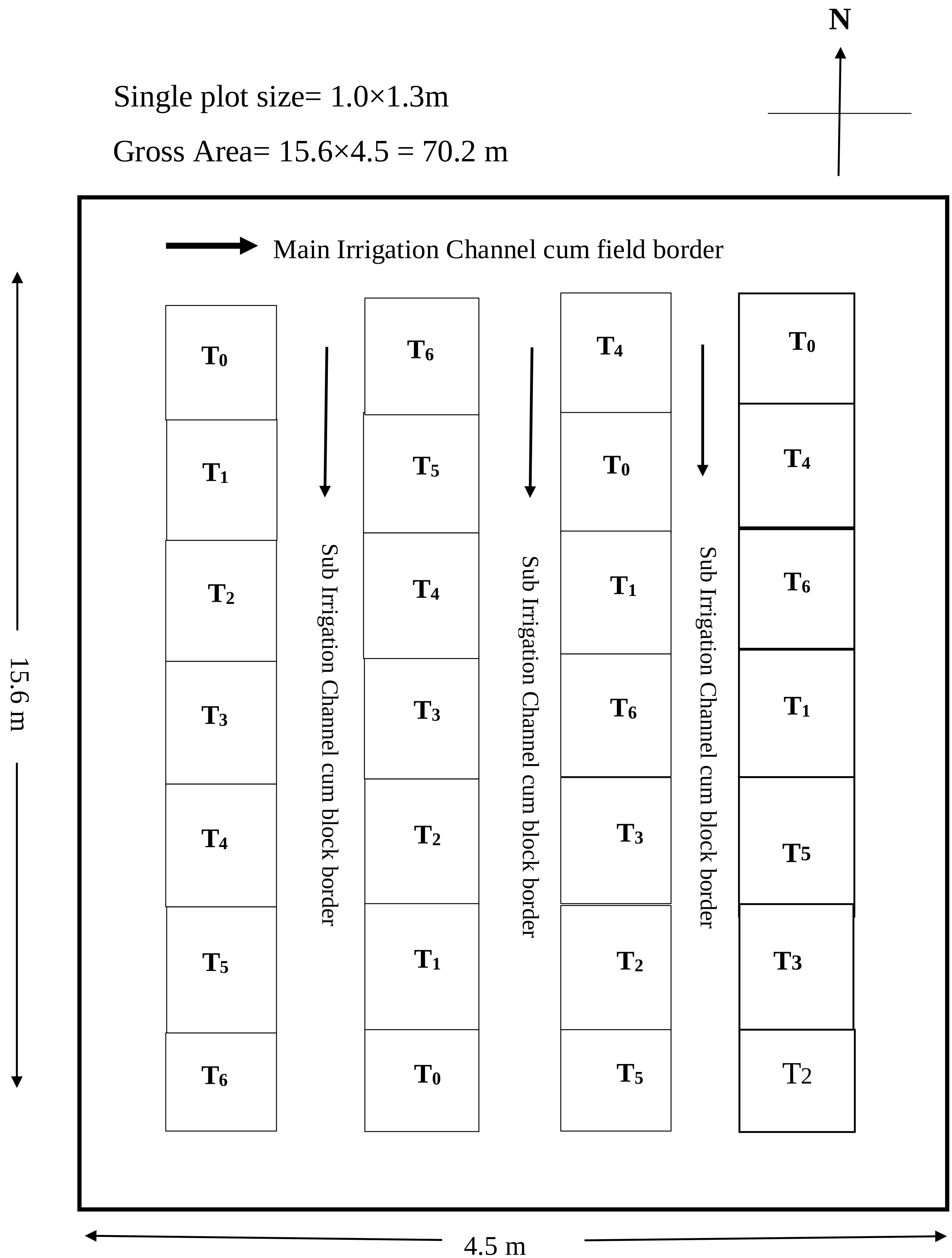
The net income per hectare was calculated on the basis of gross income and cost of cultivation per hectare of which detail is given below.

Net income = Gross income - Cost of cultivation

Economics of each treatment was worked as per given rates.

1. Field preparation (by tractor) – Rs. 265 per hour
2. Cost of manures and fertilizer per hectare
    - F.Y.M. @ Rs. 500 per ton.
    - Nitrogen in terms of urea – Rs.6.5 per kg
    - Phosphorus in terms of single super phosphate – Rs.8.4 per kg
    - Potash in terms of muriate of potash – Rs.20 per kg

3. Cost of chemicals
   - GA_3 – Rs.168 per g
   - Alar – Rs. 980 per g
   - BA – Rs. 528 per g
4. Labour charge – Rs.300/ labour/day
5. Sale price of seed – Rs.350 per 10 g
6. Market price of loose flower – Rs.40 per kg



Layout plan of the experimental field

EXPERIMENTAL FINDINGS

The present investigation was carried out in Horticultural Garden of the Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University to see the effect of different levels of GA_3, Alar and BA on growth, flower yield and vase life of China aster. The results of the experiment are described here with the help of appropriate tables and figures.

Plant height (cm)

Data pertaining to plant height are presented in Table 4.1 and graphically illustrated in Fig. 4.1 revealed a significant differences among the treatments for plant height. The maximum (34.56 cm) plant height at 30 DAP was recorded with 150 ppm GA_3 followed by 75 ppm GA_3 (31.43 cm), 20 ppm BA (28.20 cm) and 40 ppm BA (27.20 cm). The minimum (18.55 cm) plant height was recorded in 600 ppm Alar. The plant height (23.80 cm) was recorded under control which was statistically at par with 300 ppm Alar (21.33cm).

The maximum (69.77 cm) plant height at 60 DAP was recorded with 150 ppm GA_3 followed by 75 ppm GA_3 (67.13 cm), control (58.27 cm) and 20 ppm BA (58.17 cm). The minimum (50.81 cm) plant height was recorded with 600 ppm Alar. The plant height (58.27 cm) was recorded under control which was statistically at par with 20 ppm BA (58.17 cm).

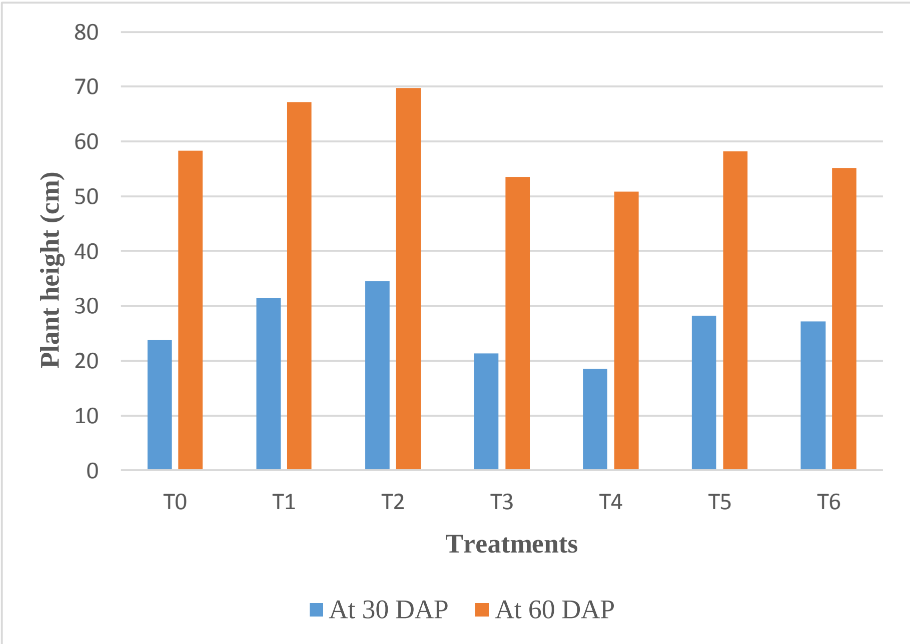
Leaf length (cm)

Data pertaining to leaf length of China aster as affected by different plant growth regulators which are presented in Table 4.2 and depicted in Fig. 4.2 The maximum (6.80 cm) leaf length was recorded under treatment 75 ppm GA_3 followed by 150 ppm GA_3 (6.72 cm), control (6.67 cm) and 40 ppm BA (6.61 cm). The minimum (6.21 cm) leaf length was recorded in 300 ppm Alar that was comparable with 600 ppm Alar (6.45 cm).

Table 4.1: Effect of GA_3, Alar and BA on plant height (cm) at different stages of growth

Treatment	At 30 DAP	At 60 DAP
T_0	23.80	58.27
T_1	31.43	67.13
T_2	34.56	69.77
T_3	21.33	53.57
T_4	18.55	50.81
T_5	28.20	58.17
T_6	27.20	55.20
SE m ±	1.17	0.99
C D at 5%	2.55	2.16

Fig. 4.1: Effect of GA_3, Alar and BA on the plant height (cm) stages of growth in days.

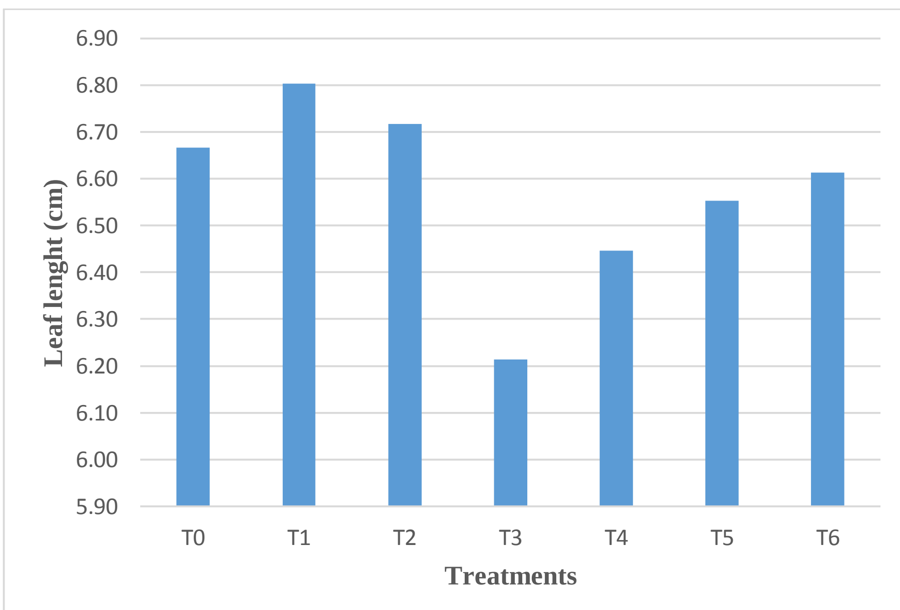


- DAP – Days after planting

Table 4.2: Effect of GA_3, Alar and BA on the leaf length (cm)

Treatment	Leaf length
T_0	6.67
T_1	6.80
T_2	6.72
T_3	6.21
T_4	6.45
T_5	6.55
T_6	6.61
SE m ±	0.12
C D at 5%	0.26

Fig.4.2: Effect of GA_3, Alar and BA on the leaf length (cm)



Leaf width (cm)

It is evident from the data presented in Table 4.3 and exhibited in Fig. 4.3 that the greatest (5.32 cm) leaf width was recorded with 40 ppm BA followed by 20 ppm BA (5.16 cm). However the remained at par with 150 ppm GA_3 (5.16 cm) and control (4.60 cm). The lowest (4.58 cm) leaf width was recorded in 75 ppm GA_3 which did not differ significantly with 30 ppm Alar.

Leaf area (cm^2)

It is obvious from data presented in Table 4.4 and depicted in Fig. 4.4 that the maximum (53.16 cm^2) leaf area was recorded under treatment 150 ppm GA_3 followed by 75 ppm GA_3 (45.83 cm^2), 40 ppm BA (41.53 cm^2) and control (40.1 cm^2). The minimum (33.16 cm^2) leaf area was recorded at 300 ppm Alar. It was statistically at par with 20 ppm BA (33.66 cm^2), 600 ppm Alar (34.36 cm^2), control (40.1 cm^2) and 40 ppm BA (41.53 cm^2).

Number of branches per plant

Data pertaining to number of branches per plant in China aster as affected by different treatments are presented in Table 4.5 and depicted in Fig. 4.5. It is clear from the data that the highest (11.90) number of branches per plant at 30 DAP was recorded with 150 ppm GA_3 followed by 75 ppm GA_3 (9.93), 600 ppm Alar (8.47) and 300 ppm Alar (8.00). The lowest (7.23) number of branches per plant was recorded under control which was statistically at par with 40 ppm BA (7.35) and 20 ppm BA (7.53).

The maximum (14.00) number of branches per plant at 60 DAP was recorded with 150 ppm GA_3 followed by 75 ppm GA_3 (11.80), control (9.87) and 600 ppm Alar (9.73). The minimum (9.27) number of branches per plant was recorded at 20 ppm BA which was statistically at par with 40 ppm BA (9.53), 300 ppm Alar (9.60), 600 ppm Alar (9.73) and control (9.87).

Table 4.3: Effect of GA_3, Alar and BA on the leaf width (cm)

Treatment	Leaf width
T_0	4.63
T_1	4.25
T_2	4.81
T_3	4.65
T_4	5.15
T_5	5.44
T_6	5.60
SE m ±	0.23
C D at 5%	0.51

Fig. 4.3: Effect of GA_3, Alar and BA on the leaf width (cm)

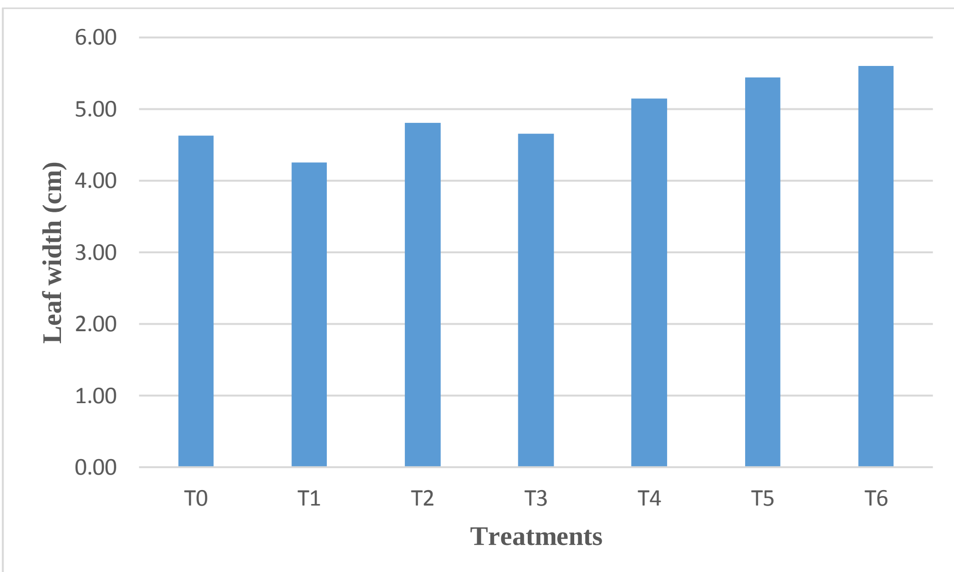


Table 4.4: Effect of GA_3, Alar and BA on the leaf area (cm^2)

Treatment	Leaf area
T_0	40.1
T_1	45.83
T_2	53.16
T_3	33.16
T_4	34.36
T_5	33.66
T_6	41.53
SE m ±	5.53
C D at 5%	12.04

Fig. 4.4: Effect of GA_3, Alar and BA on the leaf area (cm^2)

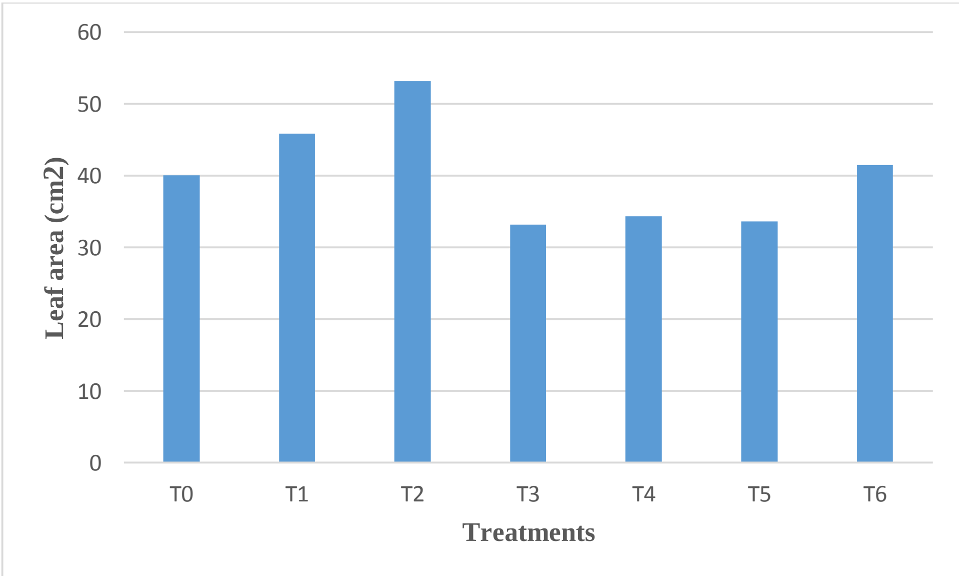
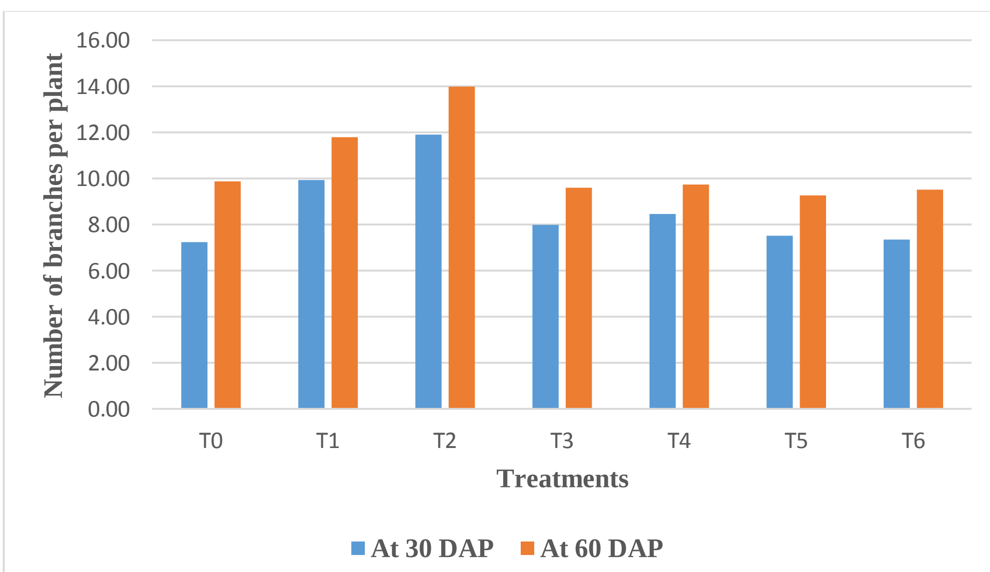


Table 4.5 Effect of GA_3, Alar and BA on number of branches per plant

Treatment	At 30 DAP	At 60 DAP
T_0	7.23	9.87
T_1	9.93	11.80
T_2	11.90	14.00
T_3	8.00	9.60
T_4	8.47	9.73
T_5	7.53	9.27
T_6	7.35	9.53
SE m ±	0.47	0.38
C D at 5%	1.03	0.82

Fig. 4.5: Effect of GA_3, Alar and BA on number of branches per plant



- DAP – Days after planting

Number of days to first flowering

Data recorded on the number of days taken to 1st flower appearance as influenced by various concentration of plant growth regulators are presented in Table 4.6 and illustrated in Fig. 4.6. The minimum (62.8) number of days was recorded with 150 ppm GA_3. The maximum (71.06) days to first flowering was recorded with 600 ppm Alar. Never the less, (69.49) for first flowering was recorded under control which was statistically at par with 20 ppm BA (67.81), 40 ppm BA (68.8) and 300 ppm Alar (69.06).

Number of flowers per plant

Data recorded on the number of flowers per plant as influenced by various concentration of plant growth regulators are presented in Table 4.7 and depicted in Fig. 4.7. The data revealed that maximum (59.53) number of flower per plant at 70 DAP was recorded under treatment 150 ppm GA_3 followed by 75 ppm GA_3 (56.53), 600 ppm Alar (56.13) and 300 ppm Alar (55.40). The minimum (47.70) number of flowers was recorded at 40 ppm BA which remained statistically at par with control (48.60) and 20 ppm BA (48.60).

The highest (75.73) number of flowers at 90 DAP was recorded with 150 ppm GA_3 followed by 600 ppm Alar (70.93), 75 ppm GA_3 (70.14) and 300 ppm Alar (70.06). The minimum (57.53) number of flower per plant was recorded under 20 ppm BA. However it remained statistically at par with control (57.9) and 40 ppm BA (58.7).

Flower diameter (cm)

Data pertaining to flower diameter as influenced by various plant growth substances have been given in Table 4.8 and graphically represented in Fig. 4.8. It is obvious from data that the maximum (5.96 cm) diameter of flower was recorded under treatment 150 ppm GA_3 followed by 75 ppm GA_3 (5.64 cm), 20 ppm BA (5.38 cm) and control (5.34 cm). The minimum (4.68 cm) diameter of flower was recorded under 600 ppm Alar. The Flower diameter (5.34 cm),

Table 4.6: Effect of GA_3, Alar and BA on number of days to first flowering

Treatment	Number of days to first flowering
T_0	69.46
T_1	65.06
T_2	62.8
T_3	69.06
T_4	71.06
T_5	67.86
T_6	68.8
SE m ±	0.84
C D at 5%	1.83

Fig. 4.6: Effect of GA_3, Alar and BA on number of days to first flowering

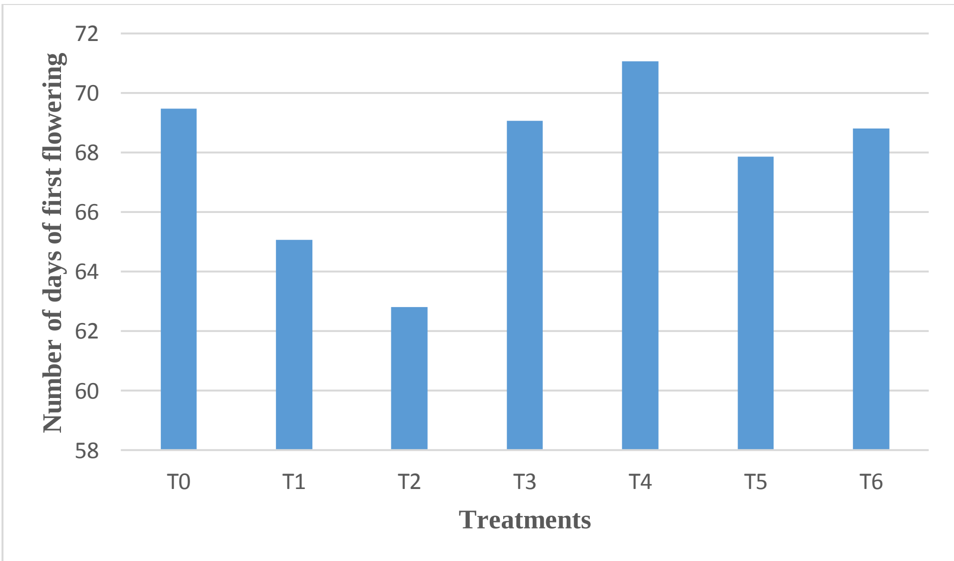
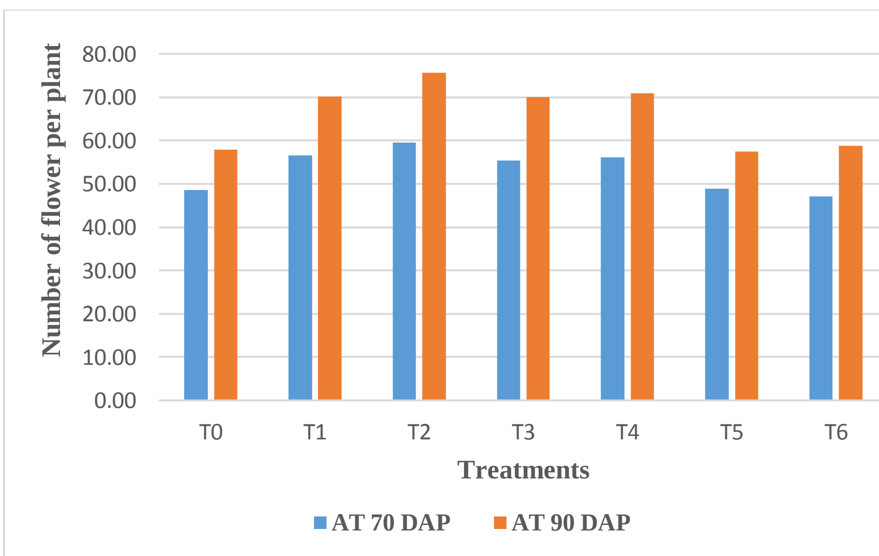


Table 4.7: Effect of GA_3, Alar and BA on number of flower per plant

Treatment	At 70 DAP	At 90 DAP
T_0	48.60	57.9
T_1	56.53	70.13
T_2	59.53	75.73
T_3	55.40	70.06
T_4	56.13	70.93
T_5	48.87	57.53
T_6	47.07	58.73
SE m ±	1.17	2.25
C D at 5%	2.55	4.90

Fig. 4.7: Effect of GA_3, Alar and BA on number of flower per plant

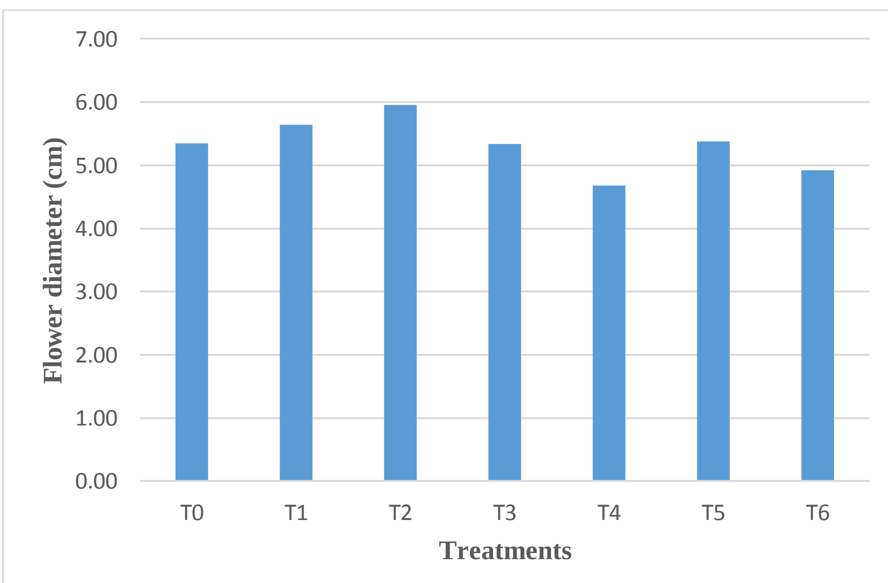


- DAP – Days after planting

Table 4.8: Effect of GA_3, Alar and BA on flower diameter (cm)

Treatment	Flower diameter (cm)
T_0	5.34
T_1	5.64
T_2	5.96
T_3	5.33
T_4	4.68
T_5	5.38
T_6	4.92
SE m ±	0.09
C D at 5%	0.19

Table 4.8 Effect of GA_3, Alar and BA on flower diameter (cm)



however, recorded under control that was statistically at par with 20 ppm BA (5.38 cm).

Fresh weight of flower (g)

Data on fresh weight of flower as affected by a GA_3, Alar and BAP are presented in Table 4.9 and depicted in Fig. 4.9. The data reveal that the highest (3.28 g) fresh weight was recorded with 150 ppm GA_3 followed by 75 ppm GA_3 (3.02 g), 40 ppm BA (2.77 g) and 300 ppm Alar (2.54 g). The lowest (2.33 g) fresh weight was recorded with 600 ppm Alar. The fresh weight of flower (2.52 g) recorded under control was equal to 20 ppm BA (2.52 g).

Dry weight of flower (g)

Data on dry weight (g) of flower as affected by GA_3, Alar and BAP are presented in Table 4.10 and depicted in Fig. 4.10. It is clear from the data that maximum (0.42 g) dry weight of flower was recorded with 150 ppm GA_3 followed by 75 ppm GA_3 (0.40 g), 300 ppm Alar (0.36 g) and 40 ppm BA (0.35 g). The minimum (0.27 g) dry weight was recorded in 600 ppm Alar. The dry weight of flower (0.33 g) recorded under control, however, was statistically at par with 40 ppm BA (0.35 g).

Flower yield per plant (g)

The data pertaining to flower yield (g) per plant as influenced by various level of plant growth regulators are presented in Table 4.11 and graphically represented in Fig. 4.11. It is obvious from data that the highest (244.26 g) flower yield per plant was recorded with 150 ppm GA_3 followed by 75 ppm GA_3 (213.48 g), 300 ppm Alar (172.41 g) and 40 ppm BA (162.90 g). The lowest (145.07g) flower yield per plant was achieved at 20 ppm BA. Flower yield (145.31 g) per plant was however, recorded under control which was statistically at par with 20 ppm BA (145.07 g).

Table 4.9: Effect of GA_3, Alar and BA on fresh weight (g) of flower

Treatment	Fresh weight
T_0	2.52
T_1	3.02
T_2	3.28
T_3	2.54
T_4	2.33
T_5	2.52
T_6	2.77
SE m ±	0.04
C D at 5%	0.08

Fig. 4.9: Effect of GA_3, Alar and BA on fresh weight (g) of flower

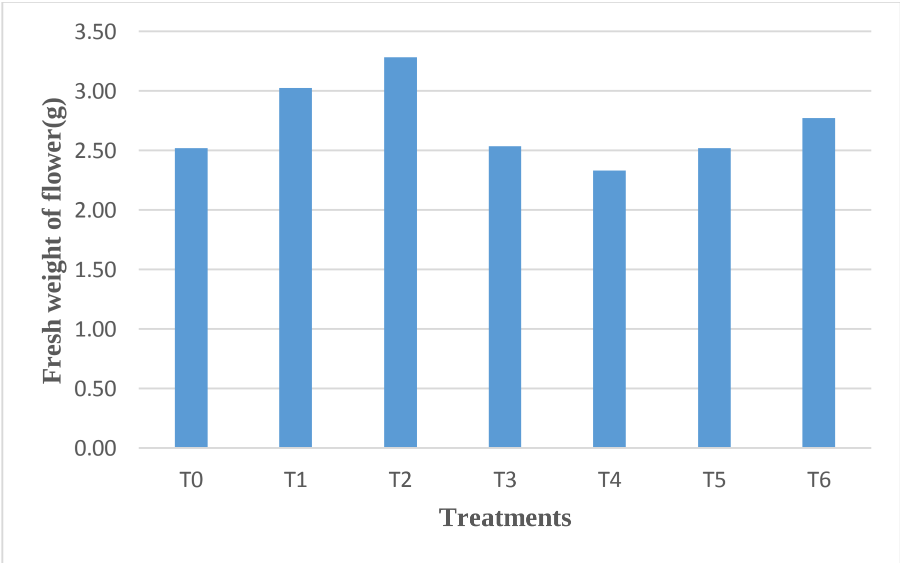


Table 4.10: Effect of GA_3, Alar and BA on dry weight (g) of flower

Treatment	Dry weight
T_0	0.33
T_1	0.40
T_2	0.42
T_3	0.36
T_4	0.27
T_5	0.32
T_6	0.35
SE m ±	0.01
C D at 5%	0.03

Fig. 4.10: Effect of GA_3, Alar and BA on dry weight (g) of flower

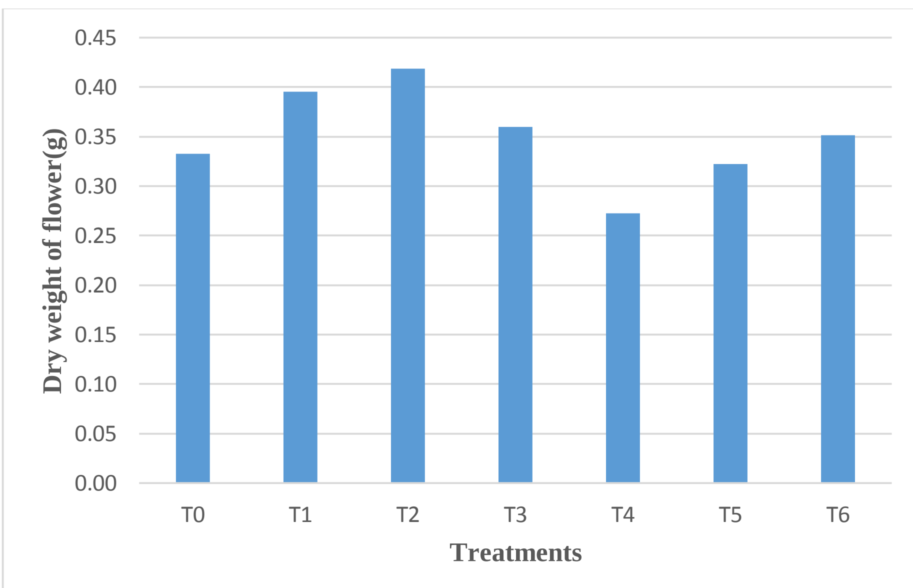
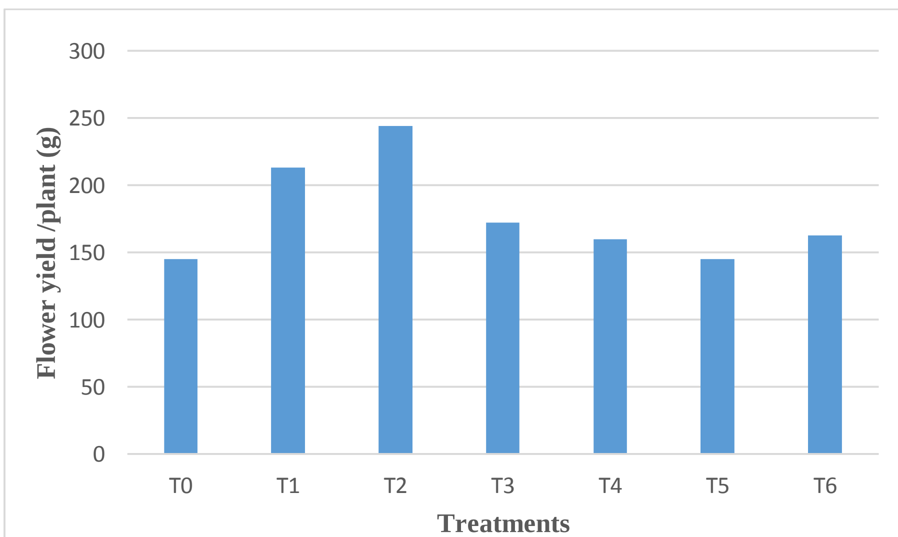


Table 4.11: Effect of GA_3, Alar and BA on flower yield per plant (g)

Treatment	Flower yield per plant
T_0	145.32
T_1	213.48
T_2	244.26
T_3	172.41
T_4	160.07
T_5	145.07
T_6	162.90
SE m ±	6.00
C D at 5%	13.06

Fig. 4.11 Effect of GA_3, Alar and BA on flower yield per plant (g)



Flower yield per plot (g)

Data recorded on flower yield (g) per plot as influenced by various concentration of plant growth regulators are presented in Table 3.12 and depicted in Fig. 3.12. The data revealed the maximum (2198.41 g) flower yield per plot was recorded with 150 ppm GA_3 followed by 75 ppm GA_3 (1921.38 g), 300 ppm Alar (1551.72 g) and 40 ppm BA (1466.14 g). The minimum (1305.71 g) flower yield per plot was noted at 20 ppm BA which was statistically at par with control (1307.87 g).

Flower yield (t/ha)

Data pertaining to flower yield (q/ha) have been presented in Table 4.13 and exhibited in Fig. 4.13 clearly reveal that the effect of treatment was obvious the greatest (16.93 t/ha) flower yield was recorded at 150 ppm GA_3 followed by 75 ppm GA_3 (14.79 t/ha), 300 ppm Alar (11.95 t/ha) and 40 ppm BA (11.29 t/ha). The minimum (10.05 t/ha) flower yield was discerned at 20 ppm BA that which remained at par with control (10.07).

Vase life (days)

Data on vase life (days) of China aster flower as affected by a $GA_{3,}$ Alar and BAP are presented in Table 4.14 and graphically depicted in Fig. 4.14. The data show that maximum (16.33) vase life was recorded with 40 ppm BA followed by 20 ppm BA (15.33) and 150 ppm $GA_{3.}$ The minimum (8.66) vase life was recorded under control. The vase life (11.33) was however, recorded at 75 ppm GA_3 which was equal to 300 ppm Alar (11.33).

Economics of different treatments in China aster plant

The observation on China aster yield and its value in terms of Rupees, cost of different treatments, net return due to treatments and net profit over control are presented in Table 4.15. Maximum yield was obtained in T_2 (GA_3 150 ppm). Consequently it conferred the highest return over the control.

Table 4.12: Effect of GA_3, Alar and BA on flower yield per plot (g)

Treatment	Flower yield
T_0	1307.87
T_1	1921.38
T_2	2198.41
T_3	1551.72
T_4	1440.67
T_5	1305.71
T_6	1466.14
SE m ±	53.96
C D at 5%	117.56

Fig. 4.12: Effect of GA_3, Alar and BA on flower yield per plot (g)

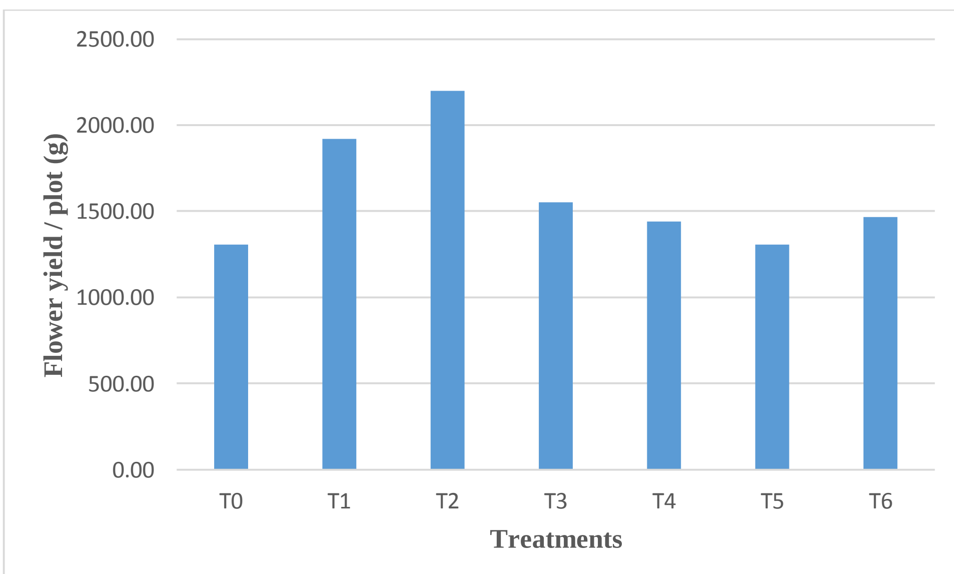


Table 4.13: Effect of GA_3, Alar and BA on flower yield (t/ha)

Treatment	Flower yield
T_0	10.07
T_1	14.79
T_2	16.93
T_3	11.95
T_4	11.09
T_5	10.05
T_6	11.29
SE m ±	0.42
C D at 5%	0.91

Fig. 4.13: Effect of GA_3, Alar and BA on flower yield (t/ha)

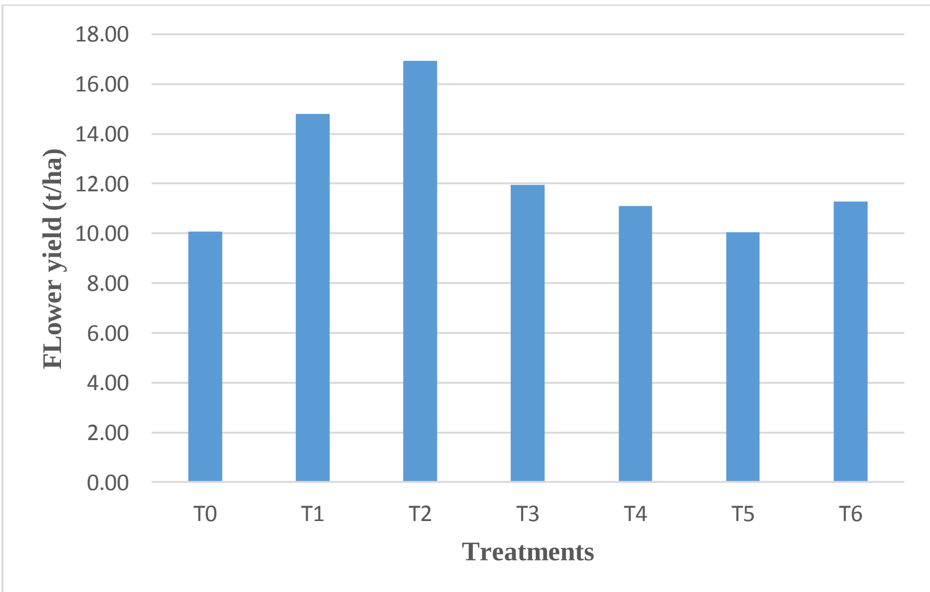


Table 4.14: Effect of GA_3, Alar and BA on vase life (days)

Treatment	Vase life
T_0	8.66
T_1	11.33
T_2	13.00
T_3	11.33
T_4	10.66
T_5	15.33
T_6	16.33
SE m ±	0.56
C D at 5%	1.22

Fig. 4.14: Effect of GA_3, Alar and BA on vase life (days)

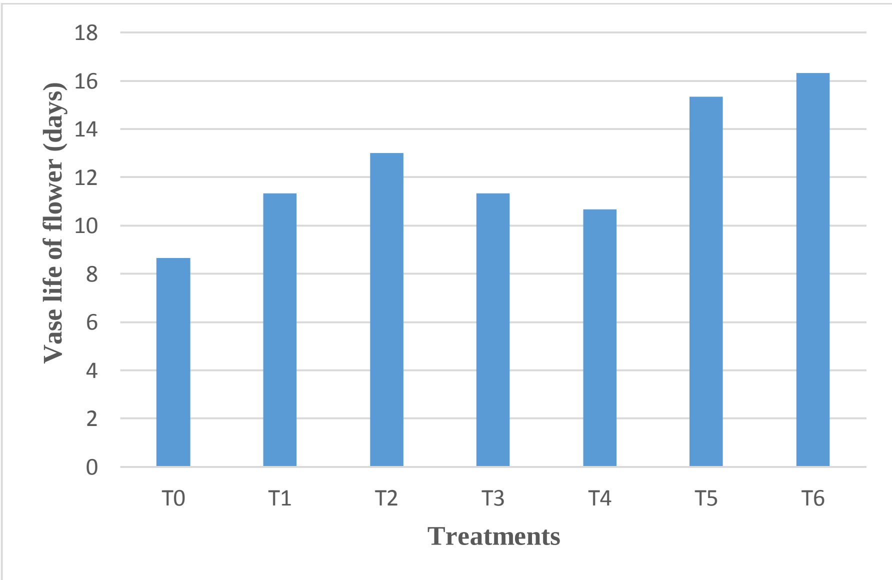


Table 4.15: Effect of various treatments on added cost and return (Rs. /ha) over Control

Treatments	Average yield (t/ha)	Total cost of cultivation (Rs.)	Total income (Rs./ha)	Net Income (Rs.)
T_0	10.07	48,576	402,800	354,224
T_1	14.79	52328	591,600	539,272
T_2	16.93	56826	677,200	620,374
T_3	11.95	60374	478,000	417,626
T_4	11.09	60856	443,600	382,744
T_5	10.05	58384	402,000	343,616
T_6	11.29	59372	451,600	392,228

DISCUSSION

The studies on the effect of GA_3, Alar and BA on the vegetative growth, flower yield and vase life of China aster (C*allistephus chinensis* (L.) Ness) was conducted at Horticultural Garden of the Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi during the year 2016-2017.The findings of present experiment are discussed and supported with the work of other scientists in the succeeding pages to provide the results scientific footings.

GROWTH PARAMETERS

Plant height

In the present study, plant growth regulators significantly influenced the plant height. GA3 150 ppm recorded the maximum (69.77 cm) plant height than Alar and BA at different concentrations.This is due to the fact that GA3 increases the growth of plant by increasing internodal length which might be due to enhanced cell division and cell enlargement and also due to increased plasticity of cell, promotion of protein synthesis coupled with higher apical dominance. Similar results were also reported by Lal and Mishra (1986), Syamal *et al.* (1990) and Doddagoudar *et al*. (2004).

Padma priya and Chezhiyan (2003) reported that maximum plant height was obtained in Chrysanthemum (*Dendranthema grandiflora*) with $GA_{3.}$ Similarly, increase of plant height by GA3 was reported earlier by Reddy and Sulladmath (1983), Prabhat Kumar *et al*. (2003), Nandre *et al*. (2009) and Padmini *et al*. (2013) in China aster and Girwani *et al*. (1990) in African marigold.

Maximum reduction in plant height was observed with the application of 600 ppm Alar. The reduction in plant height with alar application over control might be due to inhibitory role of growth retardants on cell division and cell elongation of apical meristematic cells and also on gibberellin synthesis (Cathey, 1960).

Leaf length and width

In present experiment, plant growth regulators significantly influenced the leaf length and width. The maximum (6.80 cm) leaf length was recorded with 75 ppm GA_3. The minimum (6.21 cm) leaf length was recorded under 300 ppm Alar. The maximum (5.32 cm) leaf width was recorded with 40 ppm BA. The minimum (4.58 cm) leaf width was at 75 ppm GA_3. The increase in vegetative growth due to GA3 might be due to stimulation of cell division and cell elongation with association of increasing plasticity of cell wall and formation of energy rich phosphates. Similar results were reported by Shivakumar (2000) in marigold.

Leaf area (cm^2)

Maximum leaf area was reported with GA_3 150 ppm than that of other treatments. This may be due to the increase in number of branches and also leaves. Similar results were reported by Kirad *et al.* (2001), Umrao *et al.* (2007) and Kumar *et al.* (2008). The another explanation for increased laef area might be due to thicker mesophyll tissues in leaves associated with higher chlorophyll content and making the leaves photosynthetically more active for longer period resulting in increased production of carbohydrates. Similarly Kiran Kumar (2012) reported that among the vegetative parameters, GA3 at 200 ppm increased number of leaves and leaf area over other treatments in China aster.

Number of branches

Maximum number of branches were found with GA3 150 ppm than that of other treatments. Minimum number of branches were found under control. Similar results were recorded by earlier research workers (Lal and Mishra, 1986 and Syamal *et al.*, 1990) in China aster. The increase in number of branches per plant with application of GA3 seems to be due to enhanced cell division and cell enlargement, promotion of protein synthesis coupled with higher dry matter accumulation in the plant. Similar results were also reported by Lal and Mishra (1986) in aster and marigold, Shivaprasad Shetty (1995), Doddagoudar (2002) and Kiran Kumar (2012) in China aster.

Regarding, Alar 300 ppm was very effective in producing more number of branches per plant. The physiology involved in increasing the number of branches per plant by Alar is that, this in general check, the apical dominance which can be due to lower levels of endogenous production of auxins.

FLORAL PARAMETERS

Number of days to first flowering

Minimum number of days to first flowering was recorded at 150 ppm GA_3. Maximum days to first flowering was recorded at 600 ppm Alar. These finding corroborate the results of Tomberg (1963), Reddy and Sulladamath (1983).

Number of flowers per plant:

It was observed that maximum number of flowers per plant was recorded with the 150 ppm GA_3 followed by 75 ppm GA_3 , 600 ppm Alar and 300 ppm Alar. This might be due to greater dry matter accumulation which is suggestive to better photosynthetic activity, enhancement in other metabolic activities and accelerated uptake of nutrients from soil. Therefore, the growth promoting substances might have given positive influence on the yield of flowers. The present findings are in conformity with the results of Reddy and Sulladmath (1983), Lal and Mishra (1986) in aster, Anil (2004) and Sunitha *et al.* (2007) in marigold.

The application of retardants, Alar at 600 ppm followed by 300 ppm Alar recorded maximum number of flowers per plant after GA_3. Maximum number of flowers per plant with Alar treatment than that of control might be due to suppression of vegetative growth, which resulted in diversion of photosynthates for reproductive growth.

Flower Diameter (cm)

The maximum diameter of flower was recorded with 150 ppm GA_3. The reason for enhancement of flower size may be due to increase in length of petals and pedicles or may be owing to division of photosynthates towards flower as a consequence of which there is intensification of sink (Zieslin *et al.* 1974). The results are in conformity with the studies of Reddy and Sulladmath (1983) in China aster and Rajagopalan and Abdul khader (1994) in chrysanthemum.

Girwani *et al.* (1990) also reported that GA_3 induced maximum flower diameter in African marigold. Kore *et al.* (2003) reported that GA_3 at 300 ppm recorded maximum fresh weight and size of flowers in China aster. Increase in diameter and weight of individual flower due to GA_3 application was also reported by Deotale *et al.* (1994), Sharma *et al.* (2001), Gautam *et al.* (2006) in Chrysanthemum and Kishan Swaroop *et al.* (2007) in marigold. The minimum diameter of flower was recorded at 600 ppm Alar. This may be due to insufficient availability of reserve foods during the development of flowers.

Fresh weight and Dry weight of flower

The maximum fresh weight and dry weight were recorded with 150 ppm GA_3 compared to all other treatments The increase in weight of flower in treated plants may be attributed to the fact that GA_3 promoted the efficacy of plants in terms of photosynthetic activity, uptake of nutrients and their translocation as well as better partitioning of assimilates into reproductive parts. These results are in agreement with those reported by Rakesh *et al.* (2003) in chrysanthemum. Increase in cell size due to GA_3 might have increased the diameter of flower as stated by Madhumita and Paswan (1998).

Flower yield

The increase in yield and yield parameters with GA_3 spraying might be due to better crop growth, which increased the number of flowers per plant and ultimately increased the flower yield. This can be attributed to translocation of metabolites from source to sink. Similar results were reported by Shivaprasad Shetty (1995) and Doddagoudar (2002) in China aster and Prabhat Kumar *et al.* (2003) in China aster.

Maximum flower yield per plant (g), flower yield per plot (g) and flower yield per hectare (t/ha), were recorded with the GA_3-200 ppm.This might be due to greater dry matter accumulation which is suggested that 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 results are in conformity with finding of Reddy and Sulladmath (1983) and Lal and Mishra (1986) in China aster.

Vase life (days)

One of the greatest problems in post-harvest flower physiology is the blockage of the vascular system. This blockage might be due to air or bacterial growth. Another cause of vascular blockage is the plants reactions to the actual cut.

The maximum vase life was recorded at 40 ppm BA followed by 20 ppm BA and 150 ppm $GA_{3.}$ The minimum vase life was recorded under control. The vase life was recorded at 75 ppm GA_3 was equal to vase life of 300 ppm Alar. The increased longevity of cytokinin-treated flowers might be the result of many different physiological effects of the hormone on the flower tissues. They may operate by maintaining membrane permeabilities (Kende and Baumgartner 1974), water balance (Mayak and Halew 1974) and protein and nucleic acid metabolism (Osborne, 1962).

Summary and Conclusion

The present investigation entitled "Effect of GA_3, Alar and BA on growth, flower yield and vase life of China aster (C*allistephus chinensis* (L.) Ness)" was under taken at Horticultural Field, Institute of Agricultural Sciences, Banaras Hindu University during 2016-2017. The treatments included three plant growth regulators i.e., GA_3, Alar and BA each at two levels of concentrations (GA_3 75 and 150 ppm, Alar 300 and 600 ppm and BA 20 and 40 ppm). The experiment was laid out in randomized block design with seven treatments. Each treatment was replicated thrice. The salient features of the findings are summarized in this chapter.

- The maximum (69.77 cm) plant height was found with GA_3 150 ppm, while the minimum (50.81 cm) plant height was recorded with Alar 600 ppm.
- Application of GA_3 150 ppm gave the maximum leaf area (53.16 $cm^{2)}$, while the minimum (33.16 $cm^{2)}$ leaf area was found at 300 ppm Alar.
- The maximum (14) number of branches per plant at was discovered at150 ppm GA_3, while the minimum (9.87) was under control.
- Application of GA_3 150 ppm hastened early flowering (by taking 62.8) days after transplanting whereas the maximum (71.06) days for first flowering was recorded at 600 ppm.
- GA_3 150 ppm significantly produced more (75.73) number of flower per plant than others, while the minimum (57.90) number of flower was noted under control.
- The maximum (5.96 cm) diameter of flower was recorded with 150 ppm GA_3, while minimum (4.68 cm) diameter of flower was recorded at 600 ppm Alar.
- The maximum fresh weight (3.28 g) and dry weight (0.42 g) was recorded under treatment 150 ppm GA_3 while the minimum fresh weight (2.33 g) and dry weight (0.27 g) were recorded under 600 ppm Alar.

- The maximum (16.93 t/ha) yield of flower observed with GA_3 150 ppm whereas the minimum (10.05 t/ha) at 20 ppm BA.
- The maximum (16.33 days) vase life of flower was discovered at 40 ppm BA followed by 20 ppm BA (15.33) and 150 ppm GA_3. The minimum vase life (11.33) was recorded at 75 ppm GA_3 that was equal to that at 300 ppm Alar (11.33).

Conclusion

Keeping in view the results summarized above, it is concluded that GA_3 150 ppm increased plant height, leaf area, number of branches, early flowering, maximum number of flowers per plant, flower diameter, flower fresh and dry weights and flower yield. However, BA (40 ppm) extended the vase life of flower. From economical point of view, treatment GA_3 1500 ppm was considered better as it gave higher net return as compared to other treatments.

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