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EFFECT OF GROWTH REGULATORS ON GROWTH AND FLOWERING OF CHINA ASTER [*CALLISTEPHUS CHINENSIS* (L.) NEES.]-A REVIEW

P.M. Munikrishnappa* and S.Y. Chandrashekar

Department of Floriculture and Landscape Architecture,
Post Graduate Centre, UHSB, GKVK post, Bangalore- 560 065, India

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ABSTRACT

China aster is a half hardy annual grown for loose as well as cutflowers which are used for flower arrangement, interior decoration, garlanding, worshipping *etc*. It can be grown in herbaceous borders, flower beds, garden decoration and also as potted plant. Growth regulators play an important role in morphology and physiology of the plants and their effect varies with plant, species, variety, concentration used, method of application, frequency of applications *etc*. In china aster different growth regulators *viz*., GA_3, NAA, CCC, MH and Paclobutrazol are used either for inducing or retarding growth parameters which ultimately results in better quality and increased flower yield also enhancing the vase life of cut flowers. 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). Among growth regulators foliar application of CCC at 1500 ppm recorded the highest flower yield and also flower quality parameters. Soil drench of paclobutrazol at 200 ppm delayed flowering, while early flowering was observed with 25 ppm. Application of MH at 1000 ppm resulted in minimum plant height, inter nodal length, number of leaves per plant and leaf area in china aster.

Key words: China aster, GA_3, NAA, CCC, MH, Paclobutrazol.

China aster [*Callistephus chinensis* (L.) Nees.] is a half hardy annual and commercial flower crop belonging to the family Asteraceae. It is an important annual crop of our country and grown throughout the world. In importance it ranks next to chrysanthemum and marigold among the traditional flowers. The genus *Callistephus* is derived from two Greek words *Kalistos* meaning 'most beautiful' and *Stephus*, 'a crown' referring to the flower head. The present day asters have been developed from a single form of wild species, *Callistephus chinensis*. In Karnataka it was cultivated on an area of 2194 ha, with a production of 20646 mt and productivity of 9.41 t / ha, respectively during 2009 (Anonymous., 2009). Though the flower yield and quality are primarily varietal characters, they are also greatly influenced by climatic factors like photoperiod; temperature, relative humidity, soil moisture and also the growth regulators influence both vegetative and reproductive phases of the plant, ultimately leading to variation in the performance of genotypes.

Growth regulators play an important role in changing both morphology and physiology of the plants. The effect of growth regulators varies with plant, species, variety, their concentration used, method of application, frequency of applications and various others factors which influence the absorption and translocations of the chemicals. Growth retardants are the chemical substances that slow down the cell division and cell elongation in meristematic tissues of shoot and regulate plant height without formative effects and change the morphology and physiology of the plants.

Gibberellic acid (GA_3): The work on use of GA_3 by different scientists in globe are reviewed critically and are summarized (Table-1) and presented as below.

Effect of GA_3 on growth parameters: Bose (1965) observed that an increase in plant height in china aster, dianthus, corn flower and zinnia with GA_3 treatment. Similarly, GA_3 at 250 ppm increased the

*Corresponding author's e-mail: munikrishnappapm@gmail.com

TABLE 1: Effect of GA_3 on growth, flowering and yield of china aster

Concentration of GA_3	Effect	Reported by	Year
250 ppm	Increased plant height	Bose	1965
200 ppm	Maximum plant height, number of leaves and number of branches	Symmal *et al.*	1990
200 ppm	Increased plant height and number of branches	Shivaprasad Shetty	1995
0.01%	Early flowering with increased flower size	Tomberg	1963
200 ppm	Early flowering, increased flower size and more number flowers per plant	Reddy and Suldamath	1972
200 ppm	More number of flowers per plant and increased in diameter of the flower	Lal and Mishra	1986
200 ppm	More number of flowers and seed yield	Symmal *et al.*	1990
200 ppm	Increased the plant height and number of branches per plant	Shivaprasad Shetty	1995
200 ppm	More effective in increasing plant height and highest flower yield	Naik & Katakar	2004
200 ppm	More plant height, number of branches of per plant, number of leaves per plant, seed yield per plant and per plot	Nandre *et al.*	2009

plant height and number of branches per plant compared to control in pansy and sinneraria (Singh, 1966). Spraying of GA_3 at 200 ppm recorded maximum height and more number of branches compared to control in china aster as reported by Reddy and Sulladmath, (1983) and Lal and Mishra, (1986). Syamal *et al.*, (1990) noticed the maximum height, number of leaves and number of branches in the plant treated with GA_3 at 200 ppm as compared to control in marigold and china aster. GA_3 at 200 ppm significantly increased the plant height and number of branches per plant compared to control in china aster (Shivaprasad Shetty, 1995). Naik and Katakar (2004) noticed that foliar spray of GA_3 at 200 ppm was more effective in increasing plant height and highest flower yield followed by GA_3 at 150 ppm and 100 ppm respectively in china aster. Nandre *et al.* (2009) revealed that spraying of GA_3 at 200 ppm recorded more plant height, number of branches of per plant, number of leaves per plant, seed yield per plant and per plot in china aster.

Effect of GA_3 on yield and yield components: Tomberg (1963) noticed that early flowering with increased flower size with application of 0.01 per cent of GA_3 in china aster. Induction of early flowering and increased flower size was noticed with the application of GA_3 by Reddy and Sulladamath (1972) in china aster. While, significantly more number of flower per plant was obtained by spraying of GA_3 at 200 ppm compared to control in china aster (Reddy and Sulladmath, 1983). GA_3 at 200 ppm gave more number of flowers and seed yield per plant compared to control in marigold and china aster (Syamal *et al.*, 1990). Spraying of GA_3 at 200 ppm took less number of days for 50 per cent flowering, significantly increased the number of seed heads per plant, seed yield per plant, per ha and thousand seed weight compared to control in china aster (Shivaprasad Shetty, 1995). For cut flower production foliar spray of Gibberellic acid at 150 ppm + Black Polyethylene Mulch (40 μ) + Drip Irrigation was found to optimum as reported by Srikanth *et al.*, (2013)**.** Kiran Kumar (2012) reported that among the vegetative parameters, the treatment GA_3 at 200 ppm recorded maximum values for plant height, number of branches, internodal length, number of leaves and leaf area over other treatments. 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), per plot (14.91 kg), per hectare (30.87 q) and vase life (22.88 days).

Effect of GA_3 on seed quality parameters: Shivaprasad Shetty (1995) noticed that an increase in germination percentage and vigour index in china aster by spraying of GA_3 at 200 ppm. The different growth regulators significantly affected the weight of seeds per plant. The seed weight per plant was highest in plants which were treated with 200 ppm GA_3 (7.21 g), followed by 100 ppm IAA (6.14 g) and 100 ppm GA_3 (6.21 g). GA_3 at 200 ppm also recorded the highest seed weight per ha (764.26 kg) and the highest 1000 seeds (2.358 g) weight, which was statistically superior to the control. Although 100 ppm IAA, 100 ppm GA 300 ppm GA and 50 ppm IAA increased the weight of 1000 seeds, these treatments but were found statistically at par with control (Geetha *et al.*, 2000). Doddagoudar *et al.* (2004) found that in china aster, sprayed with GA_3 at 200 ppm recorded significantly higher seedling dry weight (18.0 mg) due to higher seedling length which was found to be on par with MH at 500 ppm (17.5 mg) and it was followed by MC at 500 ppm (15.5 mg), while control recorded lowest seedling dry weight (12.8 mg) due to lower seedling length.

Seedling vigour index was also significantly influenced by all chemicals compared to control. However, maximum seedling vigour index was recorded by GA_3 at 200 ppm (496) followed by boron 0.1 per cent (463) and MH at 500 ppm (433). Nandre *et al.* (2009) revealed that spraying of GA_3 at 200 ppm recorded more seed yield per plant and per plot in china aster.

Cycocel (CCC): Use of the growth regulator CCC on china aster for retardation of vegetative growth and increasing yields as reported by different workers are presented (Table-2) and summarized as below.

Effect of CCC on growth, flowering and yield: Cycocel belongs to the group of quaternary ammonium compound analogue of chlorine which is the most active compound. It is trivial name is chloro choline chloride (CCC) and chemical name is 2- chloroethyl trimethyl ammonium chloride. Malleshappa (1984) noticed the maximum reduction in final height and the height number of branches in china aster plants pinched in nursery and sprayed with 2000 ppm. Narayana Gowda (1985) also obtained similar results but did not notice any conspicuous difference due to pinching alone. Leaf area was reduced when cycocel at 1000 ppm was sprayed in the nursery, whereas, it increased with cycocel (1000 ppm) application three weeks after transplanting. Mantur (1988) reported in china aster that the growth retardants like Alar (1000 ppm) and CCC (1000 ppm) when sprayed to the foliage produced shorter plants and maximum number of reproductive laterals. With the increase in the concentration (2000 ppm) of Alar and CCC, the suppression of plant growth was accompanied by increase in the number of lateral branches. Joshi Veena and Amarender Reddy (2006) reported that reduction in plant height with increase in concentration (500 to 2000 ppm) of cycocel and alar application over control in china aster. Rupa (2010) reported that reduced plant height, highest number of branches, number of leaves and dry matter accumulation were recorded by CCC 2400 ppm. Highest number of branches, minimum internodal length, leaf area and leaf area index are reported with MH 1500 ppm CCC 2400 ppm treatment showed delay in flower bud initiation, 50% flowering, highest number of flowers per plant and smallest flowers. But highest flower weight and yield per plant and plot were recorded with CCC 2200 ppm and for the yield per plot CCC 2000 ppm and MH 1500 ppm are at on par with CCC 2200 ppm. MH 1500 ppm treated plants showed extended flowering period, reduced stalk length and longer vase life. Application of 180 kg N/ha and CCC at 2400 ppm both expressed highest values for the biochemical parameters *i.e.*, nitrogen content, nitrogen uptake and nitrate reductase activity. (Kiran Kumar, 2012) reported that among the treatments CCC at 1500 ppm recorded minimum number of days to first floret appearance (51.68), and 50 per cent flowering (60.25).

Flowering and flower characters: Narayanagowda (1985) noticed increase in days for 50 per cent flowering due to pinching the plants and spraying with cycocel at 2000 ppm after transplanting in china aster. However, with this treatment flower diameter and peduncle length was decreased.

An experiment carried out to study the effect of growth retardants *viz.*, alar, cycocel, maleic hydrazide and TIBA at three levels each has pre harvest spray in the field to know the effect on post harvest life along with 2 per cent sucrose in three different replications. Among the treatments, the initial fresh weight was highest in alar at 1500 ppm followed by cycocel at 1000 ppm. Whereas greater fresh weight retained by flowers obtained from cycocel at 1000 ppm in china aster (Aswath *et al.*, 1995).

TABLE 2: Effect of CCC on growth, flowering and yield of flowers.

Conecntration of CCC	Effect	Reported by	Year
1000 ppm	Reduced plant height, increased number of branches, maximum dry matter production, increased flower diameter, number of flowers and flower yield	Narayanagowda	1985
2000 ppm	Suppressed plant height, more number of branches and highest flower	Mantur	1988
1500 ppm	Reduced plant height, increased branches and maximum dry matter production flower yield but delayed flowering.	Aswath *et al.*	1995
750 ppm	Maximum vase life	Katkar *et al.*	2005
500 to 2000 ppm	Reduction in plant height with increase in concentration	Veena Joshi & Amarender Reddy	2006

Yield and yield attributes: Significant increase in number of flowers was recorded when plants were pinched in nursery and sprayed with CCC at 2000 ppm and this treatment also recorded maximum dry weight of flowers in china aster (Malleshappa, 1984). Narayana Gowda (1985) recorded highest number of flowers, maximum flower yield and reduction in peduncle length in china aster due to pinching the plants 30 days after planting and CCC spray at 1000 and 2000 ppm after planting and in nursery compared to untreated control. However, maximum dry weight of flower (0.446 g) was recorded in untreated control.

Mantur (1988) observed maximum seed yield was recorded with NAA at 200 ppm followed by NAA at 500 ppm and CCC at 2000 ppm during both the seasons. Mantur (1988) reported that the growth retardants like Alar (1000 ppm) and CCC (1000 ppm) when sprayed to the foliage of china aster produced shorter plants and maximum number of reproductive laterals. With the increase in the concentration (2000 ppm) of Alar and CCC, the suppression of plant growth was accompanied by increase in the number of lateral branches. In china aster growth retardants *viz.*, MH, Alar and CCC at the rate of 1500 ppm each decreased the plant height and increased the number of main branches (Ashwath *et al.*, 1995). Narayana Gowda (1985) reported that CCC at 1000 ppm increased the number of branches, nodes and leaves in china aster. In contrast to this, a reduction in internodal length was recorded when the concentrations were increased compared to control. Aswath *et al.* (1995) noticed a decrease in plant height, branches length and internodal length with increase in the concentrations of cycocel in china aster. While, maximum number of branches and leaves were recorded in CCC 1500 ppm. Narayangowda (1985) reported in china aster that application of CCC (1000 ppm) increased the number of days to 50 per cent flowering, number of flower per plant and flower yield compared to control. Aswath *et al.* (1995) reported in china aster that application of cycocel (1000 ppm) delayed the flower bud appearance by 12.40 days. Higher number of flowers per plant were obtained due to the spray of 1500 ppm cycocel followed by alar (1500 ppm). Flower production decreased with 1500 ppm MH compared to control, further they noticed that diameter of flower was not much influenced by growth retardants. Srikanth *et al.*, (2013) revealed that cycocel treated plants along with black polyethylene mulch and drip irrigation have registered maximum diameter and girth of flower stalk. In addition, cycocel treated plants coupled with black polyethylene mulch and drip irrigation recorded more number of flowers per plant, per square metre, weight of flowers per plant, square metre and per hectare and hundred flowers which in turn registered higher cost:benefit ratio. For loose flower purpose foliar application of cycocel at 2000 ppm + Black Polyethylene Mulch (40 μ) + Drip Irrigation has emerged as the best treatment. Katkar *et al.* (2005) reported that foliar spray with cycocel at 750 ppm recorded maximum vase life followed by 500 ppm in china aster.

NAA

Effect of NAA on growth parameters: Spraying of NAA at 45, 60 and 75 ppm delayed first bud emergence and days to 50 per cent flowering in china aster cv. California Giant mix (Katkar *et al.*, 2005). Mankar *et al.* (2006) revealed that spraying of NAA and TRIA with different concentrations showed maximum plant height, plant spread, number of leaves, number of branches, maximum leaf area and leaf area index as compare to cow urine and varmiwash in china aster cv. Ostrich Plum Mixed. Kiran Kumar (2012) observed that among the vegetative parameters, the treatment GA_3 at 200 ppm recorded maximum values for plant height, number of branches, internodal length, number of leaves and leaf area over other treatments.

Paclobutrazol: Soil drenching of Paclobutrazol at 200 ppm was the most effective in retarding plant height. The highest number of branches per plant was observed with 25 ppm paclobutrazol as soil drench while lower number of branches per plant was observed with 200 ppm as soil drench. The number of leaves and total leaf area per plant significantly decreased with increased concentration of paclobutrazol irrespective of the methods of application. The soil drench method registered maximum enhancement of root:shoot ratio than foliar spray and root dip at all levels of paclobutrazol. Maximum enhancement of root:shoot length ratio was observed due to 200 ppm paclobutrazol as soil drench method. The maximum delay in flowering was recorded with 200 ppm paclobutrazol as soil drench method, while early flowering was observed with 25 ppm paclobutrazol as soil drench compared to the control. The maximum number of flowers per plant was observed with 25 ppm paclobutrazol as foliar spray. On the other hand, minimum number of flowers was recorded with 200 ppm paclobutrazol as soil drench (Mishra, 2005).

Influence of Malic Hydrazide (MH): Narayana Reddy (1978) noticed that foliar application of MH at 750 and 1000 ppm resulted in significant reduction in internodal length and increase in number of leaves and branches in china aster. Similarly, spraying of MH at 500 ppm reduced the plant height but increased the number of branches compared to control in china aster (Reddy and Sulladmath, 1983) in marigold and china aster (Lal and Mishra, 1986). Syamal *et al.* (1990) reported in decrease the height of plants, increase in number of branches, number of leaves with increase in the concentration of MH from 200 ppm to 400 ppm in china aster.

Aswath *et al.* (1995) reported that MH (1500 ppm) resulted in the reduction of plant height (38.52) number of leaves (45.59) number of branches (18.28), branch length (19.94) and internodal length (1.09) when compared to control *i.e.*, (47.56, 51.37, 15.82, 24.47 and 2.26) respectively in china aster.

Narayan Reddy (1978) reported that spraying of MH at 500, 750 and 1000 ppm thrice after transplanting in china aster delayed flowering. Further, noticed that all the concentrations reduced the diameter of flowers and flowers thickness in winter as well as in summer crops. Significantly more number of flowers per plant was obtained by spraying of china aster plants with MH at 500 ppm (Reddy and Sulladmath, 1983). Significantly, more number of flowers per plant was obtained in china aster by spraying of MH at 500 ppm compared to control (Lal and Mishra, 1986). Application of MH at 500 ppm significantly increased the number of flowers per plant compared to control in china aster. Further, there was decrease in flower diameter compared to control with 500 ppm but it was non-significant (Aswath, 1993).

Aswath *et al.* (1995) in china aster noticed that spraying of MH 500 ppm significantly

TABLE 3: Effect of NAA on growth, flowering and yield of china aster.

Crop	NAA	Effect	Reported by	Year
China aster	45, 60 and 75 ppm	Delayed first bud emergence and days to 50 per cent flowering	Katkar *et al.*,	2005
China aster	Various concentrations	Maximum plant height, plant spread, number of leaves, number of branches, maximum leaf area and leaf area index	Manakar *et al.*,	2006

increased the number of flowers per plant and also reduced the flower diameter as compared to control. Doddagoudar *et al*. (2004) reported increased 1000 seed weight, germinability, shoot and root length, seedling vigour index and seedling dry weight with MH 500 ppm spray in china aster. MH at 1000 ppm application resulted in minimum plant height, inter nodal length, number of leaves per plant and leaf area (Kiran Kumar, 2012).

To conclude, the growth regulators *viz*., GA_3, NAA, CCC, MH and Paclobutrazol have played significant role in inducing or retarding growth of china aster which ultimately results in better quality and increased flower yield also enhancing the vase life of cut flowers.

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