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Impact of plant growth regulators on the growth and flowering attributes of the China aster: A review

Ekta Rajput, Pallavi Verma and Saransh Saxena

Abstract
A review of the impact of several plant growth regulators on the development and flowering of the China aster was conducted. PGR are commonly utilized physiological and morphological manipulators that can be employed to produce flowers that are both productive and of high quality. Several growth regulators, including GA_3, NAA, IAA, CCC, and MH, are used in the case of the china aster to either promote or inhibit development parameters, resulting in higher quality and greater flower yield as well as prolonged vase life of cut flowers. Spraying GA3 at 200 ppm increased plant height, number of leaves, number of branches, plant spread, number of flowers per plant, diameter of spike, length of flower, and flower production per plant, according to the results of many experiments. When CCC was sprayed at a dosage of 1000–1500 ppm, the shortest time for bud formation, the fewest days needed for flowering, and the longest vase life were all noted.

Keywords: Plant growth regulators, flowering attributes, PGR

Introduction
Floriculture is most promising subsector in horticulture industries, which is significant from an aesthetic, social and economic perspective. It has an ability to produce year-round employment opportunities and earn foreign currency. The primary agriculture exports from many nations are various value-added goods from the floriculture industry.
China aster (*Callistephus chinensis (*L) Nees) is important half hardy, annual, cool season crop, which belongs to family asteraceae and contain diploid chromosome number 2n=18. It was originate from China in 18th century. The Greek words "Kalistos" and "Stephos," which translate to "most beautiful" and "a crown," respectively, are the source of the name of the genus *Callistephus*. *Callistephus hortensis* was the name Cassini gave to the China aster. Linnaeus gave it the original name aster *chinensis*, which Nees modified to *Callistephus chinensis*. China aster is a hybridized variety of the native Callistephus chinensis plant. Aster blooms consist of two types of flarets, ray florets and disc florets. The China aster plant is long and erect reaching a height of 75 to 80 cm. The plant has branches covered in hispid hair, which bear alternate, broadly ovate or triangular-ovate leaves with deep and irregularly toothed edges. The flowers can be solitary, single, semi-double, or double, and they come in shades of pink, violet, purple, indigo-blue, and white, which are the most noticeable colors. Aster flower is cultivated all over the world. It comes in third place among annual flowers behind marigold and chrysanthemum. It is a significant flower crop in North America, Japan, Siberia, Switzerland and Europe. The cultivation of this crop takes place throughout the year in India, mainly by marginalized and small-scale farmers in the states of Karnataka, Tamil Nadu, Andhra Pradesh, Maharashtra, and West Bengal. It has the ability to flourish in various climatic and soil conditions
These days, China aster is more often used for landscaping, cut flowers, loose flowers and other functions. flowers are also used in bouquets preparation, floral arrangements and other types of interior decoration. Loose flowers are frequently utilised in social gatherings, religious ceremonies and garlands. The dwarf cultivars of this plant are good for edging and pot purpose.
At present, China aster blossoms are currently gaining popularity among vendors and growers alike. Plant growth regulators must be non-toxic and environmentally friendly. One of the accessible and affordable physiological manipulators that can be used to increase China aster productivity and quality is plant growth regulators. Plant growth substances have been used as an effective tool to improve vegetative as well as reproductive function of plant. 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.

The utilization of plant growth substances has proven to be a highly effective means of enhancing both the vegetative and reproductive functions of plants. Plant growth regulators have become an indispensable component of floriculture, and the incorporation of growth substances represents a significant advancement in agro-technology, facilitating improvements in both the yield and quality parameters of flowers.

Impact of Gibberellic acid on growth parameters of China aster

Bhandari *et al*. (2022) [4] Reported that the application of GA_3 @ 300 ppm showed maximum plant height (55.16±0.36 cm), plant spread (12.60±0.19 cm), number of primary branches (11.77±0.40), number of secondary branches (15.66±0.50) and number of leaves per plant (148.00±2.72). According to Nandre *et al*. (2009) [10], spraying a GA_3 @ 200 ppm resulted in greater plant height, number of branches per plant, number of leaves per plant, seed yield per plant, per plot, and per hectare in china aster. Shivaprasad Shetty (1995) [9] Reported that among all the treatments, GA_3 at 200 ppm greatly enhanced the plant height and number of branches per plant compared to the control in china aster. According to Naik and Katakar (2004) [7] foliar spraying of GA_3 @ 200 ppm was more effective at boosting plant height observed that GA_3 at 200 ppm was more effective in increasing plant height in china aster. Vijay Kumar *et al*. (2017) [22] noticed that spraying GA_3 at 150 ppm showed increased plant height (69.03 cm), plant spread (37.64 cm), number of branches per plant (9.25), and number of nodes per plant (11.47) at 90 DAP in China aster**.** According to Maurya and Singh (2018), of all the treatments, GA_3 @ 150 ppm produced the highest plant height (34.56 cm and 69.77 cm), number of branches per plant (11.90 and 14.00), and leaf area (53.16 cm^2) at 30 and 60 DAP, respectively. Sonu Kumar *et al*. (2018) observed that the application of GA_3 300 ppm followed by GA_3 450 ppm resulted in maximum plant height (52.27 cm), plant spread (33.60 cm), and number of leaves per plant (90.00). 200 ppm According to Aditi B. Hande *et al.* (2022), application of GA_3 @ 150 ppm resulted in the China aster plant growing to its maximum vegetative height (70.36 cm), number of branches per plant (11.18), spread (39.88 cm), and leaf area (46.21 cm2) reported by A. R. Palekar *et al.* (2018) [2]. Maximum plant height, number of branches, leaf area, and diameter of a fully opened flower were recorded with the treatment of GA_3 @ 200 ppm. GA_3 @ 250 ppm foliar spray significantly boosted plant height, leaf area per plant, and number of leaves per plant, according to (M. K. Sharma & K. I. Josh, 2015) [15]. According to Kuri *et al*. (2018) [6], the highest plant height, plant spread, and number of leaves were 9.55, 39.29, 53.23, and 77.03 cm, 12.65, 20.52, 31.89 cm, and 39.75 cm, respectively. At 30, 60, 90, and 120 days after transplanting, the number of leaves per plant was 29.72, 74.32, 126.058, and 170.4, while the number of branches per plant was 14.39, 23.78, and 33.30. were recorded for GA_3 @ 200 ppm in China aster was measured 60, 90, and 120 days after transplanting. According to Pragnya Paramita Mishra *et al.* (2018) [14], the treatment of GA_3 @ 100 ppm resulted in maximum plant height, primary branch count, and leaf count measurements. Benny *et al*. (2017) [5] noted a substantial increase in plant height (84.82 cm), number of leaves (189.37), number of shoots (7.64), number of internodes (17.33), and intermodal length (7.37 cm) following foliar application of GA_3 @ 200 ppm. This is most likely because GA_3 encourages plant development through higher cell division and cell enlargement and a rise in apical dominance are both results of cells' greater flexibility, or enhanced protein synthesis. Another reason would be that plants used photosynthetic products more effectively as a result of gibberellins' impact on photosynthetic activity. The use of GA_3 may accelerate plant cell division and cell elongation, increasing cell quantity and length, which in turn influences the number of latent buds from which principal branches originate and promotes maximum plant dispersal. Due to promoter effects and increased cell division and cell elongation in shoot tips, GA_3 application may have increased the number of leaves and branches per plant.

Impact of GA_3 on Flowering and Post- Harvest attributes of china aster

In a study conducted by M. K. Sharma and K. I. Josh in 2015 [15], it was found that a application of GA_3 at a concentration of 250 ppm had a significant impact on the early emergence of flower buds, as well as the duration and quality of flowering. This treatment resulted in improvements in flower longevity, as well as fresh and dry weight, diameter, and overall yield in terms of both the number and weight of flowers per plant. Similarly, Kuri *et al.* (2018) [6] reported that the application of this treatment resulted in a maximum flower weight, a flower diameter, and an increased number of flowers/ plant. In 2022, Aditi B Hande *et al*. reported that the yield and quality of China aster were significantly influenced. The application of GA_3 @ 150 ppm spray resulted in the maximum flower yield per plant, per plot, and per hectare, as well as the maximum diameter of fully opened flower, stalk length, stalk diameter, and weight of flower. In 2018, Sonu Kumar *et al.* observed that the spray of GA_3 @ 200 ppm requied less days for opening of the first flower and the higher flower weight were recorded with GA_3 @ 300 ppm.(Pragnya Paramita Mishra *et al.*, 2018) [14] reported that the number of flowers and duration of flowering. Days to bud initiation, bud showing colour and flowering were earliest when sprayed thrice with 100 ppm GA_3. In 2012, Kiran Kumar reported that the application of GA_3 at a concentration of 200ppm resulted in a significant increase in the duration of flowering, number of flowers per plant, diameter, yield per hectare and vase life in China aster. Similarly, Benny *et al.* (2017) [5] observed that the foliar application of GA_3 at a concentration of 200 ppm significantly enhanced bud initiation, days to bud opening, bud length, bud diameter, flower length, flower diameter, flower stalk girth, flower stalk length, vase life, number of cut flower stalks per plot, and number of cut flower stalks per square meter. Munikrishnappa and Chandrashekar (2014) observed that the application of GA3 at a concentration of 200 ppm resulted in a significant improvement in various floral characteristics of China aster. Specifically, this treatment led to an increase in the duration of flowering, the number of flowers per plant, the diameter of individual flowers, the weight of individual flowers, the yield of flowers per plant, and the vase life of the flowers. Nandre *et al.* (2009) [10] noticed that spray of GA_3 @ 100 ppm recorded less days for flowering and 50 percent flowering were noticed. Spray of GA_3 @ 200 ppm recoded higher yield/ plant, per plot and per hectare. The role of in GA_3, whose optimal level of bud size enhancement is due to translocation of metabolites at sites of bud development, may be due to elongation of cells during flowering. Gibberellins' is recognized for its ability to enhance the sink resistance of actively growing plant parts. The augmented number of flowers may be attributed to a greater accumulation of dry matter, which is indicative of improved photosynthetic activity, metabolic processes, and nutrient uptake from the soil. Consequently, the use of growth promoters may yield a positive effect on flower production. The increased weight of flowers in treated plants can be attributed to the promotion of plant efficiency by GA_3, which enhances photosynthetic activity, nutrient uptake and transfer, and facilitates the breakdown of assimilates into reproductive parts.

Impact of Nephthaleneacetic acid on growth and flowering attributes of China aster

In a study conducted by Nandre *et al*. (2009) [10], it was observed that the application of NAA at a concentration of 100 ppm resulted in an increase in plant height (64.2 cm) and a reduction in the number of days required for the first appearance of flower buds, as well as for 50% flowering. Additionally, the flower yield per plant was found to be highest with NAA at 100 ppm (85.25 g) in China aster. Bhandari *et al*. (2022) [4] reported that NAA at a concentration of 300 ppm was effective in enhancing the shelf life of China aster. Similarly, Mankar *et al.* (2006) [13] reported that the spraying of NAA at varying concentrations resulted in maximum plant height, plant spread, number of leaves and branches, leaf area, and leaf area index in China aster. In 2005, Katkar *et al.* reported that the application of NAA at concentrations of 45, 60, and 75ppm resulted in a reduction in the number of days required for first bud initiation and days to reach 50% flowering in China aster. Similarly, in 2018, Palekar *et al.* observed that the use of NAA at a concentration of 100 ppm led to an increase in stem diameter and plant spread.

Impact of Cycocel on plant growth and flowering attributes of China aster

In 1988, Mantur observed that the application of CCC at a concentration of 1000 ppm on China aster resulted in a reduction in plant size and the maximum number of reproductive laterals. This inhibition of plant growth was accompanied by an increase in the number of lateral branches. In 2001, Ramesh *et al*. conducted an experiment on China aster cv. Kamini using various growth substances and found that the shortest duration for full flowering was achieved with a treatment of 500 ppm cycocel, as compared to the control plants. In 2010, Rupa observed that the application of CCC at a concentration of 2400 ppm resulted in a reduction in plant height, the highest number of branches, number of leaves, and dry matter accumulation.

In a study conducted by Katkar *et al.* (2005), it was reported that the application of Cycocel through foliar spray at a concentration of 750 ppm resulted in the maximum vase life of China aster flowers, followed by a concentration of 500 ppm. Kiran Kumar (2012) [8] observed that the spraying of CCC at a concentration of 1500 ppm resulted in the minimum number of days to first floret appearance and 50 percent flowering. Narayanagowda (1985) [18] recorded the highest number of flowers, maximum flower yield, and a reduction in peduncle length in China aster plants that were pinched 30 days after planting and treated with CCC spray at concentrations of 1000 and 2000 ppm after planting and in the nursery, as compared to control plants. Aswath *et al.* (1995) [3] reported that the application of Cycocel at a concentration of 1000 ppm delayed the appearance of flower buds in China aster plants, resulting in a higher number of flowers. The early onset of flowering in the Cycocel-treated plants may be attributed to the increased leaf number and leaf area, which facilitated the accumulation of sufficient nutrients during the initial stages of growth. This preliminary nutrient reserve was utilized for reproductive purposes, leading to a modification of the C:N ratio that accelerated flowering and restricted vegetative growth through the anti-gibberellin effect of Cycocel. Consequently, the early onset of flowering can also be attributed to the anti-gibberellin effect of Cycocel. The induction of floral growth achieved by the Cycocel spray may be contingent upon a reduction in endogenous gibberellin levels. The higher number of flowers per plant observed in the Cycocel-treated group compared to the control group may be due to the suppression of vegetative growth, which may have resulted in altered pathways of photosynthesis that favored reproductive growth. The exogenous application of Cycocel may have expedited photosynthetic assimilation by modifying the source/sink rate, which could have a direct impact on the synthesis of flowering hormones and, consequently, the transition of plants from vegetative to reproductive stages, resulting in a greater number of flowers per branch per plant.

Conclusion

The plant growth regulators gibberellins, Naphthalene acetic acid and Cycocel have played a significant role in inducing or retarding the vegetative growth of China aster flower plant, ultimately resulting in improved flower quality and increased flower yield. Additionally, these regulators have been found to increase the vase life of cut flowers and self-life of the loose flowers.

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