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Growth, flowering and quality of China aster flowers influenced by various plant growth regulators

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Abstract
An experiment to study the effect of plant growth regulators on growth, flowering and flower quality of China aster was carried out during *rabi* season of the year 2017-18 at Satpuda Botanical Garden, Horticulture Section, College of Agriculture, Nagpur. A field experiment comprised with ten treatments *viz.*, GA_3 100 ppm, GA_3 150 ppm, GA_3 200 ppm, IAA 50 ppm, IAA 100 ppm, IAA 150 ppm, NAA 25 ppm, NAA 50 ppm and NAA 100 ppm and Control. The treatments were replicated three times in a Randomized Block Design.
The result of the present investigation indicated that, significantly maximum plant height, number of branches, leaf area and diameter of fully opened flower were recorded with the treatment of GA_3 200 ppm. Whereas, stem diameter and plant spread were recorded higher with the treatment of NAA 100 ppm. In respect of flowering characters *viz.*, days to first flower bud initiation, opening of flower from bud emergence and 50 per cent flowering in China aster were recorded to be minimum under the treatment of GA_3 150 ppm also GA_3 150 ppm concentration recorded maximum weight of flower.

Keywords: Plant growth regulators, GA_3, IAA, NAA, growth, flowering, quality, China aster

Introduction
The total area under floriculture crops in India in 2016-17 was estimated to be 309 thousand hectares with approximate production of 1653 thousand metric tons of loose flowers and 593 thousand metric tons of cut flowers. The total export of floriculture products and flowers in India during 2016-2017 was 22,086 metric tons and costing Rs. 54,873.96 Lacs (Anonymous, 2017) [1].
China aster (*Callistephus chinensis* L.) is to be considered as one of the important commercial flower crops belonging to the family Asteraceae. It is native to China and has spread to Europe and other countries during 1731 AD. The genus *Callistephus* is derived from two Greek words Kalistos meaning 'most beautiful' and Stephus means 'a crown' referring to the flower head. China aster is an important commercial ornamental annual grown in many parts of the world. It is a hardy and free blooming annual grown all over the world on account of its ease of cultivation, greater diversity in forms and colours and their long vase life has made them popular as cut flower amongst the growers. It is grown for its loose flowers as well as cut flowers.
Plant growth regulators are numerous chemical substances that profoundly influence growth and differentiation of plant cells, tissues and organs. Plant growth regulators function as chemical messenger for intercellular communication and thus, it plays 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.

Materials and Methods
The present investigation was carried out during *rabi* season of the year 2017-18 at Satpuda Botanical Garden, Horticulture Section, College of Agriculture, Nagpur to study the effect of plant growth regulators on growth, flowering and flower quality of China aster. The research was carried out on the variety Phule Ganesh White. A field experiment was laid out with ten treatments *viz.*, GA_3 100 ppm (T_1), GA_3 150 ppm (T_2), GA_3 200 ppm (T_3), IAA 50 ppm (T_4),

IAA 100 ppm (T_5), IAA 150 ppm (T_6), NAA 25 ppm (T_7), NAA 50 ppm (T_8) and NAA 100 ppm (T_9) and Control (T_{10}).
The treatments were replicated three times in a Randomized Block Design. The seedlings were prepared in protray in polyhouse of Satpuda Botanical Garden. The protrays were watered regularly still transplanting of seedling in the field. Seedlings were allowed to grow up to 30 days and then transplanting was done in the experimental plot. The uniform size, healthy and 30 days old seedlings were selected for transplanting. The seedlings were transplanted on flat bed by planting of one healthy seedling hill^{-1} at the spacing of 30 cm x 30 cm distance. The recommended dose of fertilizer (150: 50: 50 kg NPK ha^{-1}) was applied to all the plots in the form of urea, single super phosphate and muriate of potash. Out of this, full dose of P and K and 1/2 dose of nitrogen was applied at the time of transplanting. The remaining 1/2 dose of nitrogen was applied at 30 days after transplanting.
The stock solutions of GA_3, IAA and NAA were prepared by taking the required quantity of chemicals and dissolving them initially in a small quantity of absolute alcohol and there after diluted with water as per the treatment concentration. The growth regulators of the respective concentration were sprayed twice at 20 and 40 DAT with the help of hand sprayer. The whole plants were sprayed completely by taking precaution to avoid the mixing of spray from one treatment to another.
Observations on growth parameters *viz.*, plant height, number of branches and stem diameter were recorded at 90 DAT, plant spread and leaf area were recorded at 50% flowering, on flowering parameters *viz.*, days to first flower bud initiation, days to opening of flower from bud emergence, days to 50 per cent flowering were recorded in days, also quality parameters *viz.*, diameter of fully opened flower and weight of flower after harvesting.

Result and Discussion

Growth Parameters

The data presented in table 1 revealed that, at 90 DAT, significantly maximum plant height was recorded with the treatment (T_3) GA_3 200 ppm (74.46 cm) which was found to be statistically at par with treatment (T_2) GA_3 150 ppm (73.08 cm). However, minimum plant height was recorded with the treatment (T_9) NAA 100 ppm (52.78 cm). This might be due to the fact that, an application of gibberellic acid at different concentrations might have enhanced the plant height by increasing the internodal length as a result of increased cell elongation and faster cell division. The results are in conformity with the findings of Kumar *et al.* (2015) [2] who reported that GA_3 200 mg/l spray recorded significantly higher plant height (60.10 cm) in China aster and Palei *et al.* (2016) [4] who quoted as GA_3 100 ppm showed the maximum plant height (36.55 cm) in African marigold. However, the reduction in plant height due to application of NAA at higher concentration might have caused ethylene formation which is correlated with an inhibition of plant growth instead of promoting the cell division. Similar inhibition of linear growth of African marigold plant with higher concentration of NAA was also noticed by Patil *et al.* (2014) [5].
As regards number of branches (10.47) and leaf area (44.49 cm^2) had recorded significantly maximum with the treatment (T_3) GA_3 200 ppm. Maximum number of branches with spray of gibberellic acid due to fact that, GA_3 is known to influence translocation and transcription mechanism of protein biosynthesis, also stimulation of cell division and cell elongation while increasing plasticity of cell wall and formation of energy rich phosphates resulting in an increased plant height with more number of productive branches. The present study confirms the results of Kumar *et al.* (2015) [2] who reported that GA_3 200 mg/l spray recorded significantly higher plant height (60.10 cm), number of primary branches per plant (24.60) and number of secondary branches per plant (61.45) in China aster. Thus, the treatment of GA_3 200 ppm noted maximum leaf area in China aster. This might be due to the fact that, gibberellic acid plays a vital role in improvement of vegetative growth characters of the plants as it enhances the cell division by promoting the DNA synthesis in the cells. Further, GA_3 is also known to increase the sink strength of the actively growing plant parts. This would have resulted into the better leaf area of China aster plants. The findings are in close agreement with the findings of Sharma and Joshi (2015) [6] who reported as GA_3 @ 250 ppm foliar spray significantly increased plant height (56.18 cm) and leaf area plant^{-1} (3968.88 cm^2) in China aster.
As regards maximum stem diameter (1.38 cm) and plant spread (31.32 cm) was recorded significantly with the treatment (T_9) NAA 100 ppm and minimum stem diameter (0.99 cm) and plant spread (23.70 cm) was recorded in control i.e. treatment (T_{10}). An increased stem diameter of plant was observed with the increase in concentration of NAA. It might be due to reduction in plant height as a result of application of higher concentration of NAA which might have caused the utilization of food material for development of stem and produced maximum stem diameter. Similar results were found by Patil *et al.* (2014) [5] who reported that treatment of NAA 400 ppm followed by NAA 300 ppm was recorded significantly maximum stem diameter (1.39 cm) and spread of plant (34.90 cm) in African marigold.

Flowering Parameters

Data regarding flowering parameters are presented in table 1. The treatment (T_2) GA_3 150 ppm took significantly minimum period for first flower bud initiation (58.86 days), opening of flower from bud emergence (8.12 days) and 50 per cent flowering (78.31 days) and maximum number of days required for first flower bud initiation (73.93 days), opening of flower from bud emergence (11.61 days) and 50 per cent flowering (96.26 days) was recorded with the application of NAA 100 ppm (T_9). The foliar treatment of gibberellic acid might have stimulated and enhanced the vegetative growth by increasing photosynthesis and respiration with enhanced carbon-di-oxide fixation in the treated plants which would have associated with an early flowering. Further, gibberellin is quite effective in reducing the juvenile period of the plants. At the termination of juvenile phase, the shoot apical meristem might have converted into the flower premordia instead of producing leaves. The results obtained in the present investigation are in close agreement with the findings of Palei *et al.* (2016) [4] in African marigold and Vijayakumar *et al.* (2017^b) [8] in China aster.

Quality Parameters

The data presented in table 1 revealed that, the treatment (T_3) GA_3 200 ppm noted significantly the maximum diameter of flower (6.97 cm) and it was found to be at par with the treatments (T_2) GA_3 150 ppm (6.95 cm), (T_1) GA_3 100 ppm (6.44 cm), (T_8) NAA 50 ppm (6.19 cm) and (T_9) NAA 100 ppm (5.83 cm). Whereas, significantly minimum diameter of flower (4.86 cm) was recorded with the treatment (T_5) IAA 100 ppm. The maximum flower diameter in China aster was observed with the plants treated with gibberellic acid. This

might be due to active cell elongation in the flower caused increase in length of petals and pedicels or may be owing to division of photosynthates towards flower as a consequence of which there is intensification of sink in China aster. The findings are in line with the results obtained by Maurya *et al.* (2017) [3] who quoted as spraying of GA_3 150 ppm resulted maximum flower diameter (5.96 cm).

Also the treatment (T_2) GA_3 150 ppm had recorded significantly the maximum weight of flower (4.34 g) and it was found statistically at par with the treatments (T_3) GA_3 200 ppm (4.23 g), (T_1) GA_3 100 ppm (4.16 g), (T_6) IAA 150 ppm (3.96 g), (T_8) NAA 50 ppm (3.91 g), (T_9) NAA 100 ppm (3.84 g) and (T_7) NAA 25 ppm (3.78 g), whereas, significantly minimum weight of a flower (3.11 g) was recorded with the treatment (T_{10}) control. It is due to the fact that gibberellic acid promotes 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. The results obtained during this investigation are closely in agreement with the findings of Vijayakumar *et al.* (2017[a]) [7] who reported as spraying of GA_3 at 150 ppm increased flower diameter (6.91 cm) and flower weight (3.92 g) in China aster.

From the study and given data it can be inferred that, application of gibberellic acid is superior over IAA and NAA with respect to growth, flowering and flower quality of China aster.

Table 1: Growth, Flowering and flower quality parameters influenced by plant growth regulators

Treatments	Plant height at 90 DAT (cm)	Number of branches at 90 DAT	Stem diameter at 90 DAT (cm)	Plant spread at 50% flowering (cm)	Leaf area at 50% flowering (cm^2)	Days to first flower bud initiation	Days to opening of flower from bud emergence	Days to 50% flowering	Diameter of flower (cm)	Weight of flower (g)
T_1 - GA_3 100 ppm	69.47	9.80	1.02	24.55	41.25	63.10	8.90	82.42	6.44	4.16
T_2 - GA_3 150 ppm	73.08	10.27	1.09	23.51	43.85	59.70	8.12	78.31	6.95	4.34
T_3 - GA_3 200 ppm	74.46	10.47	1.12	21.36	44.49	62.45	8.43	81.48	6.97	4.23
T_4 - IAA 50 ppm	62.02	8.20	1.26	27.12	35.42	66.31	9.36	89.61	5.16	3.29
T_5 - IAA 100 ppm	59.49	7.80	1.21	27.87	36.61	68.25	9.88	92.62	4.86	3.89
T_6 - IAA 150 ppm	59.08	7.73	1.32	29.37	37.34	69.74	10.41	94.57	5.32	3.96
T_7 - NAA 25 ppm	63.93	8.40	1.36	29.16	39.88	66.59	10.21	93.44	5.48	3.78
T_8 - NAA 50 ppm	55.13	10.07	1.37	30.69	41.56	70.55	10.73	94.65	6.19	3.91
T_9 - NAA 100 ppm	52.78	9.47	1.38	31.32	40.38	73.93	11.61	96.26	5.83	3.84
T_{10} - Control	66.03	8.13	0.99	19.23	34.52	64.21	10.17	87.55	5.37	3.11
SE (m) ±	1.174	0.341	0.021	1.664	1.313	1.219	0.624	1.134	0.401	0.231
CD at 5%	3.489	1.041	0.061	4.944	3.904	3.622	1.854	3.371	1.193	0.686

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