Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(2): 19-21
Received: 11-01-2018
Accepted: 13-02-2018

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Responses of plant growth regulators on China aster (*Callistephus chinensis*)

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Abstract
Study the responses of plant growth regulators on China aster (*Callistephus chinensis*) a field experiment was carried out during winters of 2016-17 at Horticulture Research Farm, Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. China aster is cultivated as cut flower both in the field and under protected condition in temperate countries, whereas, in India, it is widely grown in Karnataka, Tamil Nadu, West Bengal and Maharashtra for cut as well as loose flower production. The experiment was laid out in Randomized Block Design with seven treatments and four replications comprising two levels of GA_3 (75 and 150 ppm), Alar (300 and 600 ppm) and BA (20 and 40 ppm) with Control. All variables regarding growth and flower yield were significantly influenced by different concentrations of the treatments. Among all the treatments GA_3 (150 ppm) resulted in maximum plant height (34.56 cm and 69.77 cm after 30 and 60 days of planting respectively), number of branches/plant (11.90 and 14.00 after 30 and 60 days of planting respectively), leaf area (53.16 cm^2) and flower yield (244.26 g/plant). Maximum leaf length (6.80 cm) and leaf width (5.60 cm) recorded under the treatments GA_3 (75 ppm) and BA (40 ppm) respectively and also observed the highest return in terms of Rupees, cost of different treatments, net return due to treatments and net profit over control was found best in treatment T_2 (GA_3 150 ppm).

Keywords: growth, flower, yield, GA_3, Alar, BA and growth promoting substances

Introduction
China aster (*Callistephus chinensis*) is a half hardy and easy growing winter annual belongs to family Asteraceae. China aster is mainly cultivated for Cut flowers, have good vase life and are used in flower arrangements vases, bouquets and for interior decorations etc. and loose flowers are widely used for making garlands, for decoration, for worship and are also used in social functions. Due to their different plant heights they are highly suitable in garden landscape and are grown in different features viz., flower beds, borders and potted plants.
Increased flower production, quality of flowers and perfection in the form of plants are the important objectives to be reckoned in commercial flower production. Though the quality of cut flowers is primarily a varietal trait, it is greatly influenced by climatic, geographical and nutritional factors. The requirement of fertilizer can be reduced by manipulating physiological process of plant. Plant growth regulators are one of the cheap and widely used physiological manipulators which can be used for productivity and quality enhancement in China aster. Plant growth substances have been used as an effective tool to improve vegetative as well as reproductive function of plant (Meena *et al*., 2017) [6]. Even the same growth regulator at different dose can bring about different results. These are considered as new generations of agrochemicals after fertilizers, insecticides and herbicides. Keeping these points in view, the present study was under taken to ascertain the most suitable concentration of GA_3, Alar and BA for better growth and high flower yield of China aster.

Materials and Methods
The present investigation was carried out during winters of 2016-17 at the Horticulture Research farm, Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh (India). The soil of experimental field was Indo-Gangetic alluvial in origin. The experiment was laid out in Randomized Block Design with seven treatments and three replications. The treatments included T_0: control, T_1: GA_3 (75 ppm), T_2: GA_3 (150 ppm), T_3: Alar (300 ppm), T_4: Alar (600 ppm), T_5: BA (20 ppm) and T_6: BA (40 ppm). Standard cultural practices recommended for China aster was followed uniformly for all the experimental plots. The treatments were imposed as foliar spray at 30 days after transplanting. The observations on growth (at 30 and 60 DAP) and flower yield were recorded and analyzed statistically as per the procedure described by Panse and Sukhatme (1985) [8].

Results and Discussion

GA_3 150 ppm recorded the maximum (69.77 cm) plant height than Alar and BA at different concentrations (Fig.1). This may due to the fact that GA_3 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) [6], Shyamal *et al*. (1990) [11] and Doddagoudar *et al*. (2004) [2]. 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) [1].

Maximum numbers of branches were found with GA_3 150 ppm than that of other treatments (Table 1). Minimum number of branches was found under control. Similar results were recorded by earlier research workers (Lal and Mishra, 1986 and Shyamal *et al*., 1990) [11, 6] in China aster. The increase in number of branches per plant with application of GA_3 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) [5] in aster and marigold, Doddagoudar (2002) [2] and Kumar (2012) [4] 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 checks, the apical dominance which can be due to lower levels of endogenous production of auxins.

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 treatment 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 by GA_3 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 (Shivakumar, 2000) [10]. Maximum (53.16) leaf area and leaf area index (0.0886) 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) [3], Umrao *et al*. (2007) [12] and Kumar *et al*. (2008) [5]. The another explanation for increased leaf area might be due to thicker mesophyll tissues in leaves associated with higher chlorophyll content and making the leaves photo-synthetically more active for longer period resulting in increased production of carbohydrates.

The maximum (244.26 g plant^{-1}) flower yield was recorded at 150 ppm GA_3 and minimum (145.07 g plant^{-1}) flower yield was discerned at 20 ppm BA that which remained at par with control (145.32). 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 findings of Reddy and Sulladmath (1983) [9] and Lal and Mishra (1986) [6] in China aster.

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 Table2. Maximum yield was obtained in GA_3 150 ppm, consequently it conferred the highest return over the control.

Table 1: Effect of various treatments of PGR on number of branches (plant^{-1}), leaf length (cm), leaf width (cm) and leaf area (cm^2)

Treatment	Number of branches (plant^{-1})		Leaf length (cm)	Leaf width (cm)	Leaf area (cm^2)
	30 Dap*	60 Dap*			
Control (T_0)	7.23	9.87	6.67	4.63	40.1
GA_3 75 ppm (T_1)	9.93	11.80	6.80	4.25	45.83
GA_3 150 ppm (T_2)	11.90	14.00	6.72	4.81	53.16
Alar 300 ppm (T_3)	8.00	9.60	6.21	4.65	33.16
Alar 600 ppm (T_4)	8.47	9.73	6.45	5.15	34.36
BA 20 ppm (T_5)	7.53	9.27	6.55	5.44	33.66
BA 40 ppm (T_6)	7.35	9.53	6.61	5.60	41.53
CD (P = 0.05)	0.47	0.38	0.12	0.23	5.53

*DAP- Days after planting

Table 2: Effect of various treatments on added cost and return (Rs ha^{-1}) over Control

Treatments	Average yield (t ha^{-1})	Total cost of cultivation (Rs)	Total income (Rs ha^{-1})	Net Income (Rs)
Control(T_0)	10.07	48,576	402,800	354,224
GA_3 (75 ppm)T_1	14.79	52328	591,600	539,272
GA_3 (150 ppm)T_2	16.93	56826	677,200	620,374
Alar(300 ppm)T_3	11.95	60374	478,000	417,626
Alar (600 ppm) T_4	11.09	60856	443,600	382,744
BA(20 ppm)T_5	10.05	58384	402,000	343,616
BA(40 ppm)T_6	11.29	59372	451,600	392,228

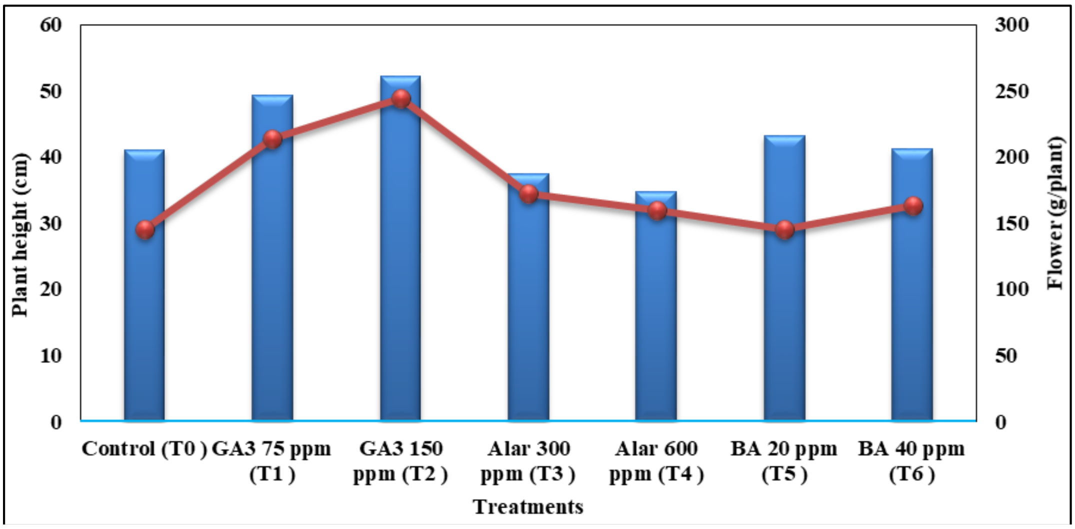

Fig 1: Effect of various treatments of PGR on plant height (cm) and flower yield (g/plant)

Acknowledgements

Sincere thanks to Head, Department Horticulture, Institute of Agricultural Sciences, Banaras Hindu University. Author also thankful to Anupam Kumar Tiwari for preparation in manuscript.

Conflict of interest

The authors did not declare any conflict of interest.

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