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Response of China aster (*Callistephus chinensis* L.) to pinching and growth regulators for vegetative and yield characters under Konkan agro-climatic conditions

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Abstract
The present investigation entitled "Response of China aster (*Callistephus chinensis* L.) to pinching and growth regulators for vegetative and yield characters under Konkan agro-climatic conditions" was carried out at Department of Floriculture and Landscape Architecture College of Horticulture, DBSKKV, Dapoli Dist. Ratnagiri, Maharashtra at High-Tech nursery, during year 2021-22. Presently, The Experiment was laid out in factorial randomised block design with 20 treatment combinations of cv. Phule Ganesh Pink. The experiment comprised of P_1: no pinching, P_2: pinching at 3 weeks after transplanting, P_3: pinching at 5 weeks after transplanting and P_4: double pinching and methods as sub factor *viz*., T_1-control (water spray), T_2 (GA_3 200 ppm), T_3 (GA_3 300 ppm), T_4 (CCC 1000 ppm), T_5 (CCC 1500 ppm) replicated thrice. In respect of pinching methods, yield was noticed significantly maximum with double pinching. In case of growth regulators, maximum plant height, number of flowers was recorded on the application of GA_3 (300 ppm). Whereas, Maximum plant spread was observed on the application of CCC (1500 ppm). In treatment combination P_4T_3 were found significantly superior with respect to number of leaves, leaf area, number of flowers and yield of flowers. Pinching and plant regulators act as inducing or decreasing in plant height and spread which ultimately gives more yield.

Keywords: China aster, growth regulators, pinching, maximum

Introduction
Floriculture is an emerging science being perceived as a lucrative business and now considered to be one of the most important and escalating commercial trade in agriculture for its attractive flower as well as aesthetic value across in world. It is recognized business since it has higher potential per unit area than most of the field crops even horticultural crops both for domestic market and export. Among the flower, China aster (*Callistephus schinesis* L.) which is commonly known as aster is one of the most popular showy and free blooming annuals belonging to family Asteraceae. It is believed to have originated in China. Among the annual flowers, it ranks next to chrysanthemum and marigold. The flowers are solitary and blue lavender rose and white are the prominent colours. In recent years, China aster has gained more popularity due to its multifarious uses including cut flower, loose flower and landscaping purposes. It can be grown almost throughout the year, however under Konkan conditions can be grown only in winter season. It can easily be grown in the open fields and lath houses for the production of cut flower.
There is a great scope for increasing area under China aster in Konkan region as soil and climatic conditions are well suited for its cultivation. Special horticultural practices are important for optimum growth, high yield and good quality flowers. Pinching is one of the most suitable practice for successful cultivation of cut flowers as well as potted plants. Pinching simply mean removing the terminal growing portion of stem due to apical dominance. Growth and development of plants are under the control of extremely minute quantity of hormone within the plant themselves. Production of improved quality flower depends greatly on the use of plant growth regulators at commercial level. The growth and flowering of China aster are greatly influenced by judicious application of plant growth regulators. Therefore, it is imperative to find out optimum doses plant growth regulators, for quality flower production. Deficiency of plant growth regulators results in poor growth and flowering. Plant growth regulators GA_3, CCC play important role in breaking dormancy,

manipulating growth, flowering, vegetative growth and the yield of several crops. The present study is therefore, undertaken to investigate the possibilities of improving production and quality of China aster.

2. Materials and Methods

The present investigation was carried out at Department of Floriculture and Landscape Architecture, College of Horticulture, DBSKKV, Dapoli Dist. Ratnagiri, Maharashtra at High-Tech nursery, during year 2021-22. The experiment was laid out in Factorial Randomized Block Design with 20 treatment combinations comprising of P_1: No pinching, P_2: pinching at 3 weeks after transplanting, P_3: pinching at 5 weeks after transplanting and P_4: double pinching and methods as sub factor *viz*., T_1-Control (water spray), T_2 (GA_3 200 ppm), T_3 (GA_3 300 ppm), T_4 (CCC 1000 ppm), T_5 (CCC 1500 ppm) replicated thrice. The net plots with 2.3 × 1.85 m size were prepared by following preparatory tillage operations and transplanting of 45 days old healthy and uniformly grown seedlings of cv. Phule Ganesh Pink was done at 45 cm X 45 cm spacing. The spraying with different growth regulators was done at 30 days after transplanting while pinching was done at 3 weeks and 5 weeks after transplanting. The observations on the vegetative characters *viz.*, plant height, spread, number of branches, number of leaves, leaf area and yield were recorded at 30 days after transplanting. The data were statistically analyzed by the method suggested by Panse and Sukhatme (1985) [9].

3. Results and Discussion

The data present in table no. 1 revealed that, among the treatment combination of no pinching with GA_3 300 ppm (26.14cm, 69.23cm and 77.38cm, respectively) was significantly maximum plant height, similarly, the lowest plant height was detected in treatment combination of pinching at 3 to 5 weeks after transplanting with CCC 1500 ppm (20.73 cm, 45.93 cm and 59.44 cm, respectively) at 45,75and 105 days. The increase in plant height with increase in GA_3 concentration is observed in current experiment. This is 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 (Reddy and Sulladmath, 1983) [11]. And also due to increased plasticity of cell, promotion of protein synthesis coupled with higher apical dominance. The GA_3 through foliar spray were absorbed by the leaves and translocated in plant system through xylem and phloem tissue in readily format. Similar results were also reported by Maurya and Singh (2018) [7], Kumar *et al.* (2018), Vijay Kumar *et al.* (2017) [4], Kuri *et al.* (2018) [6], Sunna *et al.* (2021) [13], Nandre *et al.* (2009) [8], Sindhuja and Prasad (2018) [12] in China aster. In cycocel treated plant, it might have reacted with gibberelic acid or IAA oxidase to lower down the level of diffusible auxin thereby suppressing the vegetative growth. The shortened plant height might be due to combined effect of CCC and pinching was due to the role of cycocel in inhibition of gibberellin biosynthesis which results in cell elongation and also by the supression of apical dominance by inhibiting cell division. Coupled with the removal of apical meristimatic tissues which inhibited the apical dominance by pinching practice. Growth might also be increased due to osmotic uptake of water and nutrients under the influence of GA_3 which maintain swelling force against the softening of cell wall and thereby increasing the plant height. Maximum average plant spread was recorded in treatment combination of pinching at 3 to 5 weeks after transplanting with CCC 1500 ppm at 45, 75 and 105 days interval (30.29 cm, 53.18 cm and 68.52 cm, respectively). The minimum average plant spread was found in treatment combination of no pinching with GA_3 300 ppm at 45, 75 and 105 days interval (25.06 cm, 35.15 cm and 48.46cm, respectively). Increased in the plant spread may be due to suppression of apical dominance by higher concentration of growth regulators or pinching that produced greater number of lateral branches, resulting in increased plant spread. Significant increase in average plant spread in China aster due to pinching is might be due to suppression of apical dominance that produce a maximum number of main and lateral branches which is resulting in increased average plant spread in both direction. This is lined by Chopde *et al.* (2019) [1], Thakare *et al.* (2020) [14], Gaidhani *et al.* (2020) [2], Maurya and Singh (2018) [7] and Sunna *et al.* (2021) [13] in China aster.

The interaction study shows that maximum number of primary and secondary branches was recorded in pinching at 3 to 5 weeks after transplanting with GA_3 300 ppm at final stage of harvesting (22.41 and 68.37) and the minimum number of primary and secondary branches (9.07 and 41.70) was noted in treatment control. Thus, from obtained data we can conclude that just GA_3 at 300 ppm can able to produce significantly higher number of secondary branches. As an application of GA_3 enhanced cell division and cell enlargement, promotion of protein synthesis and stimulation of branching may be attributed to the removal of apical dominance by the pinching we performed. The result obtaining maximum number of branches due to pinching is might be due to suppression of apical dominance that produce higher number of lateral branches. This result supported the findings of Khobragade *et al.* (2012) [3], Kumar *et al.* (2014), Pawar (2019) [10], Thakare *et al.* (2020) [14], Gaidhani *et al.* (2020) [2] in Nandre *et al*. (2009) [8], Kumar *et al.* (2018) [18], Kumar *et al.* (2017) [17], Kuri *et al.* (2018) [6], Maurya and Singh (2018) [7] and Sunna *et al*. (2021) [13] in China aster. Significantly maximum number of leaves was registered in treatment combination of pinching at 3 to 5 weeks after transplanting with GA_3 at 300 ppm at final stage of harvesting (80.62 and 7284.40 cm^2). The minimum number of leaves was recorded in treatment control at final stage of harvesting (42.97 and 2185.71 cm^2). Due to sufficient light intensity received by the plant due to adequate pinching levels might have caused synthesis of food as well as primary physiological effect of auxin is to stimulate the elongation of cells due to increased amylase activity. Pinching also reduces the apical dominance and enhance lateral growth of plant and The GA_3 is known to increase the sink strength of the actively growing plant parts, producing more number of branches and thus more leaves. This might have been reason for increasing number of leaves and average leaf area in China aster. Similar results were also observed by Khobragade *et al.* (2012), Thakare *et al.* (2020) [14] and Gaidhani *et al.* (2020) [2] and Chopde *et al.* (2017) Nandre *et al.* (2009) [8], Kumar *et al*. (2017), Kumar *et al*. (2018) and Kuri *et al*. (2018) [6] in China aster. Minimum leaf area was also observed with plants treated with CCC. This is might be due to that cycocel reacted with gibberelic acid or IAA oxidase to lower down the level of diffusible auxin there by suppressing the vegetative growth ultimately utilized for lateral branching and reduced leaf area.

3.1 Flower yield parameter

During the period of research, the interaction effect between pinching and growth regulator flower yield per plant of China aster was significant showed in table no. 2. It is observed that maximum number of flowers per plant, flower yield per plant (g), per plot (kg) and yield per hector (q) (72.96, 389.58, 7.79 and 159.11, respectively) was recorded in treatment combination of pinching at 3 to 5 weeks after transplanting with GA_3 300ppm. The minimum flower yield per plant (g), per plot (g) and yield per hector (q) (47.32, 94.00, 1.88 and 67.51) was recorded in control. Pinching and higher concentration of growth regulators checked the apical dominance and diverted extra metabolites into the production of more number of flowers. Pinching temporarily reduces auxin which takes away the apical dominance. This enables to the side buds to start growing. Increase in flower yield might be due to suppression of apical dominance resulting in more number of primary and secondary branching, thereby increasing the flower number which ultimately resulted in increased yields of flowers. An increase in yield due to more vigorous growth of plant and maximum number of productive shoots per plant due to the production and accumulation of more photosynthates. The results confirm with findings of Khobragade *et al.* (2012) [3], Thakare *et al.* (2020) [14], Gaidhani *et al.* (2020) [2] in China aster. The most impressive yield of flowers per plant, plot and hectare was recorded with treatment GA_3 at 300 ppm. The influence of raising the flower yield was due to increase number of branches which led to increase in the number of flowers. After successful vegetative phase only, the plant could step into reproductive phase with better yield. The increase in yield and yield parameters with GA_3 at 300 ppm spraying was due to enhanced reproductive efficiency and photosynthesis in restructured plant type producing more number of flowers per plant and ultimately increased the flower yield per plot and per hectare. Also Similar trend were reported by Reddy and Sulladmath (1983) [11] in China aster. Maximum number of flowers per plant with cycocel treatment than the control might be due to suppression of vegetative growth, which might have resulted in diversion of photosynthates for reproductive growth. Sindhuja and Prasad V.M (2018) [12].

Table 1: Effect of pinching and growth regulators on vegetative characters of China aster cv. Phule Ganesh Pink

Treatment Details	Plant height(cm)			Plant spread(cm)			Primary branches	Secondary branches	Number of leaves	Leaf area (cm^2)
	45 DAT	75 DAT	105 DAT	45 DAT	75 DAT	105 DAT				
P_1T_1	25.25	58.06	71.41	25.56	41.65	53.30	9.07	41.70	42.97	2185.71
P_1T_2	25.20	65.63	75.77	25.52	38.78	51.26	12.33	55.97	45.80	2501.78
P_1T_3	26.14	69.23	77.38	25.06	35.15	48.46	12.78	57.37	46.17	2560.39
P_1T_4	24.07	56.33	67.45	25.58	44.55	53.49	9.43	52.77	44.03	2309.45
P_1T_5	23.97	53.87	65.91	25.60	47.38	56.04	10.19	54.10	44.47	2392.94
P_2T_1	22.40	55.35	69.19	25.77	43.32	56.38	13.00	56.34	47.66	2654.22
P_2T_2	23.57	60.73	72.70	25.71	42.38	55.42	13.70	57.73	53.47	3578.37
P_2T_3	24.23	65.17	73.40	25.73	37.27	54.66	14.49	59.60	55.10	3726.49
P_2T_4	23.13	53.40	64.70	25.86	47.36	57.41	13.10	56.71	48.25	2733.60
P_2T_5	22.71	51.49	64.50	25.95	49.27	58.67	13.51	57.16	48.85	3074.62
P_3T_1	25.07	56.07	67.50	26.23	45.63	57.35	14.83	58.37	56.16	3786.33
P_3T_2	23.77	58.80	69.23	26.09	42.87	56.73	16.71	62.88	61.42	4625.93
P_3T_3	24.43	62.80	71.17	25.97	37.34	54.38	17.00	64.57	62.27	4740.47
P_3T_4	23.77	52.17	64.67	26.32	49.08	62.74	15.00	59.70	57.09	4097.39
P_3T_5	23.80	49.67	61.87	26.37	50.18	63.12	16.00	61.06	60.03	4439.49
P_4T_1	22.90	52.00	65.78	26.82	47.06	63.89	16.39	60.96	63.52	4901.89
P_4T_2	23.30	56.73	65.20	26.51	44.45	62.92	21.00	65.01	79.40	7097.58
P_4T_3	22.87	59.37	66.77	26.39	38.17	62.47	22.41	68.37	80.62	7284.40
P_4T_4	21.83	47.60	62.60	28.10	51.14	65.53	18.33	61.55	75.83	6595.33
P_4T_5	20.73	45.93	59.44	30.29	53.18	68.52	19.37	62.19	77.13	6743.03
SEm ±	0.383	0.661	0.815	0.392	0.505	0.648	0.247	0.662	0.661	48.697
CD at 5%	1.10	1.89	2.33	1.12	1.45	1.85	0.71	1.90	1.89	139.42

Table 2: Effect of pinching and growth regulators on yield characters of China aster cv. Phule Ganesh Pink

Treatment Details	Number of flowers	Flower yield/plant(g)	Flower yield/plot(kg)	Flower yield/hectare(q)
P_1T_1	47.32	94.00	1.88	44.18
P_1T_2	52.14	140.97	2.82	66.25
P_1T_3	55.51	157.20	3.14	78.22
P_1T_4	48.40	112.31	2.25	52.79
P_1T_5	50.11	118.84	2.38	55.85
P_2T_1	54.98	170.69	3.41	80.22
P_2T_2	59.37	221.16	4.42	103.95
P_2T_3	59.86	229.66	4.59	105.94
P_2T_4	58.42	198.24	3.96	93.17
P_2T_5	57.41	218.74	4.37	102.81
P_3T_1	59.53	235.73	4.71	106.46
P_3T_2	63.22	256.78	5.17	117.06
P_3T_3	63.39	257.60	5.29	118.68
P_3T_4	61.55	253.60	5.07	114.53

P_3T_5	62.21	253.65	5.14	116.46
P_4T_1	63.10	271.75	5.43	124.73
P_4T_2	67.95	313.20	6.26	145.54
P_4T_3	72.96	389.58	7.79	157.78
P_4T_4	63.88	277.72	5.55	126.86
P_4T_5	64.66	287.04	5.74	132.58
SEm ±	0.682	7.191	0.146	1.160
CD at 5%	0.9640	20.59	0.42	3.32

Levels of Growth Regulators :	**Levels of Pinching :**
1) T_1– Control	1) P_1 - No pinching
2) T_2 – GA_3 @ 200 ppm at 30 DAT	2) P_2 – Pinching after 3 weeks of transplanting
3) T_3 – GA_3 @ 300 ppm at 30 DAT	3) P_3 – Pinching after 5 weeks of transplanting
4) T_4 – CCC @ 1000 ppm at 30 DAT	4) P_4 – Double pinching (Pinching after 3 and 5 weeks of transplanting
5) T_5 – CCC @ 1500 ppm at 30 DAT	

4. Conclusion
From the present investigation it is concluded that, the interaction effect between pinching and growth regulator had significant effect on the vegetative as well as yield parameter. The treatment combination of pinching at 3 and 5 weeks after transplanting with GA_3@ 300ppm found best with respect to number of leaves, leaf area, number of flowers per plant as well as yield per plant, yield per plot, yield per ha in China aster cv. Phule Ganesh Pink. Whereas, increasing in plant height in treatment combination of no pinching with GA_3 300ppm as well as plant spread of treatment combination pinching at 3 and 5 weeks after transplanting with CCC 1500ppm.

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