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Effect of plant growth regulators on vegetative, floral and yield characters of China Aster (*Callistephus chinensis* (L.) Nees.) cv. Phule Ganesh purple

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Abstract
The present investigation entitled "Effect of plant growth regulators on vegetative, floral and yield characters of China aster (*Callistephus chinensis* (L.) Nees.) cv. Phule Ganesh Purple" was under taken at Department of Horticulture, Naini Agriculture Institute, Sam Higginbottom university of Agriculture, Technology and Sciences (SHUATS), during the year 2017-18 with thirteen treatments which replicated thrice in a Randomized Complete Block Design. The treatments comprising of GA_3, NAA, Triacontanol and their different concentrations along with control. The results of the study revealed that floral attributes like maximum flower diameter flower weight, flower yield per hectare was observed from the plants grown in plots receiving GA_3 @ 200 ppm. Among the treatments applied the minimum duration for bud initiation, minimum days to flowering with maximum vase life were recorded in Triacontanol. However maximum days taken to bud and flower initiation was recorded in control. Thus, it can be concluded that application of GA_3 @ 200 ppm can be recommended for commercial cultivation of China aster cv. Phule Ganesh Purple.

Keywords: China aster, GA_3, NAA, triacontanol, flower yield and vase life

Introduction

China aster is one of the most important annual flower crops grown in many parts of the world. Among annual flowers, its rank third next only to chrysanthemum and marigold. It has spread to Europe and other tropical countries during 1731 A.D. It is also an important flower crop of Siberia, USSR, Japan, North America, Switzerland and Europe. It is grown successfully in open conditions for year round production in kharif, rabi and summer to have continuous supply of flowers to the market. The flowers have long vase life and are used for various purposes. It is used for the preparation of garlands, in bouquets as fillers, flower arrangements, in flower shows and exhibitions. It is popular as a bedding plant and is also used in herbaceous borders in gardens. It is grown as a potted plant and its dwarf cultivars are suitable for edges. It is an erect hispid hairy branched annual with ovate or triangular ovate leaves spirally attached on stems (Cockshull, 1985 and Webb *et al*., 1988) [2, 18].

Plant growth regulators play an important role in flower production, which in small amount promotes or inhibits or quantitatively modifies growth and development. Plant growth regulators play an important role in flower production, which in small amount promotes or inhibits or quantitatively modifies growth and development. Growth regulators find their extensive use in ornamental crops for modifying their developmental process. Plant growth regulators play an important role in flower production, which in small amount promotes or inhibits or quantitatively modifies growth and development. Plant flowering and growth very depended on PGRs equilibrium and plants quickly respond to change of hormonal balance (Khangoli, 2001) [5].

Materials and Methods

The Experimental was conducted in Randomized Block Design (RBD) with 13 treatments and three replications China Aster in the Departmental Research field of Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad during the November, 2017 to March, 2018. Total number of Treatments were thirteen *viz.* T_0 (Control), T_1 (GA_3 @ 50 ppm), T_2 (GA_3 @ 100 ppm), T_3 (GA_3 @ 150 ppm), T_4 (GA_3 @ 200 ppm), T_5 (NAA @ 50 ppm), T_6 (NAA @ 100 ppm), T_7 (NAA @ 150 ppm), T_8 (NAA @ 200 ppm), T_9 (Triacontanol @ 500 ppm), T_{10} (Triacontanol @ 1000 ppm), T_{11} (Triacontanol @ 1500 ppm) and T_{12} (Triacontanol @ 2000 ppm). Recommended dose of manures and fertilizers were applied in each treatments.

Climatic condition in the experimental site

The area of Allahabad district comes under subtropical belt in the south east of Utter Pradesh, which experience extremely hot summer and fairly cold winter. The maximum temperature of the location reaches up to 46 °C-48 °C and seldom falls as low as 4 °C- 5 °C. The relative humidity ranges between 20 to 94%. The average rainfall in this area is around 1013.4 mm annually. However, occasional precipitation is also not uncommon during winter months.

Results and Discussion

The present investigation entitled "Effect of plant growth regulators on vegetative, floral and yield characters of China aster (*Callistephus chinensis* L (L.) Nees.) cv. Phule Ganesh Purple" was carried out during November, 2017 to March, 2018 in Departmental Research Field of Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad (U.P.) India. The results of the present investigation, regarding the effect of Plant growth regulators on Vegetative, floral and Yield characters of China aster, have been discussed and interpreted in the light of previous research work done in India and abroad. The experiment was conducted in Randomized block design with 13 treatments, and three replications.

The results of the experiment are summarized below

Growth Parameters

Plant height was recorded maximum (9.55, 39.29, 58.34 and 77.03 cm) at 30, 60, 90 and 120 days interval after transplanting in treatment T_4 (GA_3 @ 200 ppm), followed by T_3 (GA_3 @ 150 ppm) with (9.36, 34.58, 53.23 and 73.81 cm). The minimum plant height was recorded in T_{12} (TRIACO @ 2000 ppm) with (7.45, 13.43, 32.36 and 53.43 cm). This is due to the fact that GA_3 increased 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. Another probable reason of significant increase in plant height might be due to the effect of gibberellins on photosynthetic activity resulted in efficiently utilizing photosynthetic products by the plants. These findings are in commensurate with the reports of Kumar *et al.* (2008) and Chopde *et al.* (2013) [6, 1].

Plant spread (12.65, 20.52, 31.89 and 39.75 cm) at 30, 60, 90 and 120 days interval after transplanting was recorded with the treatment T_4 (GA_3 @ 200 ppm), which was found at par with the treatment T_3 (GA_3 @ 150 ppm) with (12.34, 19.74, 30.42 and 38.98 cm). The minimum plant spread was recorded in T_0 (Control) with (7.91, 10.71, 19.78 and 24.71 cm). After studying the observation of plant spread it can be said that maximum plant spread might be due to the application of gibberellic acid which increases cell division and cell elongation in plants resulting in more number of cells and increase in cell length which ultimately affects plant spread.Similar results were also reported by Gupta *et al*. (2015) [4], Munikrishnappa *et al*. (2014) [9].

Number of leaves/plant (29.72, 74.32, 126.05 and 170.4) at 30, 60, 90 and 120 days interval after transplanting was recorded with the treatment T_4 (GA_3 @ 200 ppm), which was found at par with the treatment T_3 (GA_3 @ 150 ppm) with (28.52, 72.31, 116.41 and 162.42) Number of leaves/plant. The minimum number of leaves was recorded in T_0 (Control) with (19.25, 39.85, 73.47 and 94.46) Number of leaves/plant. An increase in number of leaves with the application of GA3 might have been resulted due to promotory action of gibberellic acid on dormancy of gladiolus corms and an enhanced cell division in shoot tip and cell elongation. These results can be correlated with the findings of Sudhakar *et al.* (2012) [14] and Ravidas *et al.* (1992) [13].

Number of branches/plant (14.39, 23.78 and 33.30) at 60, 90 and 120 days interval after transplanting was recorded with the treatment T_4 (GA_3 @ 200 ppm), which was found at par with the treatment T_3 (GA_3 @ 150 ppm) with (14.12, 23.15 and 29.61) Number of Branches/plant. The minimum number of branches was recorded in T_8 (NAA @ 200 ppm) with (10.47, 18.29 and 23.51) Number of Branches/plant at 60, 90 and 120 days interval. An increase in number of branches with the application of GA3 might have been resulted due to promotory action of gibberellic acid on dormancy of gladiolus corms and an enhanced cell division in shoot tip and cell elongation. These results can be correlated with the findings of Sudhakar *et al.* (2012) [14] and Ravidas *et al.* (1992) [13].

Flowering and yield parameters

Application of different plant growth regulators showed significant effect on Days taken to flower bud initiation. In the treatment where the plants are treated with T_{11} (TRIACO@ 1500 ppm) was first to show its visible flower bud (51.75 DAS) and was on par with T_{12} (52.85DAS). Whereas in the treatment T_0 (control) was late to initiate flower bud (63.95DAS). The reason for such result may be the availability of optimum quantity of TRIACO@ 1500 ppm under this treatment resulting in significantly reduced Days to flower bud initiation. This is in accordance with the findings of Vijayakumar *et al.*, (2017) [17]. They reported that the minimum number of days taken to first floret open was found with treatment of TRIACO@ 1500 ppm foliar.

Days taken to 50% bud initiation was recorded minimum in treatment T_{11} (TRIACO@ 1500 ppm) with (60.69 days) followed by treatment T_{12} with (61.92 days).Whereas, in the treatment T_0 (control) was late to show 50% bud initiation (74.21DAS). The reason for such result may be the availability of optimum quantity of TRIACO@ 1500 ppm under this treatment resulting in significantly reduced days taken for 50% bud initiation. This is in accordance with the findings of Vijayakumar *et al*., (2017) [17]. They reported that the minimum number of days taken to first floret open was found with treatment of TRIACO@ 1500 ppm foliar.

Days taken to first flowering, in the treatment where the plants are treated with T_{11} (TRIACO@ 1500 ppm) was first to show less number of days to first flowering (65.94 days) and was on par with T_{12} (66.44 days). Whereas in the treatment T_0 (control) was late to show first flowering (80.96 days). The reason for such result may be the availability of optimum quantity of TRIACO@ 1500 ppm under this treatment resulting in significantly reduced days taken for first flowering. This is in accordance with the findings of Vijayakumar *et al*., (2017) [17]. They reported that the minimum number of days taken to first floret open was found with treatment of TRIACO@ 1500 ppm foliar.

Days taken for 50% flowering was recorded minimum in Treatment T_{11} (TRIACO @ 1500 ppm) with (70.62 days) for 50% flowering which was found to be at par with T_{12} (71.24 days).Whereas, the treatment T_0 (86.36 days) was took more number of days for 50% flowering. The reason for such result may be the availability of optimum quantity of TRIACO@ 1500 ppm under this treatment resulting in significantly reduceddays taken for 50% flowering. This is in accordance with the findings of Vijayakumar *et al*., (2017) [17]. They reported that the minimum number of days taken to first floret open was found with treatment of TRIACO@ 1500 ppm foliar.

Flower diameter (cm) (7.50 cm) was recorded in treatment T_4 (GA_3 @ 200ppm) which was found to be on par with T_3 (6.88 cm).Whereas, the significantly lower flower diameter (4.71) was observed in T_0 (control). The superiority of treatment T4 (GA_3 @ 200ppm) amongst the various treatments may be due the role of GA3 which in optimum level improving the bud size may be ascribed to the translocation of metabolites at the site of bud development. Increase in diameter of floret might be due to cell elongation in the flower. Gibberellins are also known to increase the sink strength of actively growing parts. The similar findings were also noted by Ram *et al.* (2001) [12], Patel *et al.* (2013) [11] and Chopde *et al.* (2013) [1].

Flower weight of individual flower was recorded maximum (6.79 g) in treatment T_4 (GA_3 @ 200ppm) which was found to be on par with T_3 (6.79 g).Whereas, the significantly lower flower weight (4.18 g) was observed in T_0 (control). The superiority of treatment T4 (GA_3 @ 200ppm) amongst the various treatments may be due the role of GA_3 which in optimum level improving the bud size may be ascribed to the translocation of metabolites at the site of bud development. Increase in diameter of floret might be due to cell elongation in the flower. Gibberellins are also known to increase the sink strength of actively growing parts. The similar findings were also noted by Ram *et al*. (2001) [12], Patel *et al*. (2013) [11] and Chopde *et al*. (2013) [1].

Number of Flowers/plant (72.83) was noticed in the treatment T_4 (GA_3 @ 200ppm) compared to all other treatments. Treatment T_0 (control) resulted into significantly lesser number of flowers per plant (35.14) over other treatments. Number of flowers per plant was also more in the treatment T_4 this may be due to the influence of plant growth regulators. Similar findings were reported by Munikrishnappa *et al*. (2014) [9], Padmalatha *et al*. (2015) [10].

Flower yield/plant (395.71 g), Flower yield/plot (4723.79g) and Flower yield t/hectare (13.87 t) was recorded maximum in the treatment T_4 (GA_3 @ 200ppm) which was found to be on par with T_3 (341.68 g) flower yield/plant, (4075.58g) flower yield/plot and (12.14t) flower yield/ha.Whereas, the significantly lower flower yield/plant, Flower yield/plot and Flower yield t/ha (101.52g), (1194.01g) and (4.42 t) respectively was observed in treatment T_0 (control). Increase in spike length in treatment may be attributed due to the fact that optimum level of GA_3 promoted the efficacy of plants in terms of photosynthetic activity enhanced the uptake of nutrients and their translocation, better partitioning of assimilates into reproductive parts. Similar result was recorded by Kumar (2012) [7], Munikrishnappa *et al*. (2014) [9].

Quality Parameters

Significant differences were found among the different treatment application with respect to vase life of flowers at room temperature. Treatment T_{11} (TRIACO@ 1500 ppm) possessed vase life of 9 days followed by T_4 (10.25 days, GA_3 @ 200 ppm).Whereas least number of days (8.31) recorded in treatment T_0 (control). One of the greatest problems in post harvest flower physiology is the blockage of the vascular system. This blockage might be due to air or bacterial growth. Another cause of vascular blockage is the plants reactions to the actual cut. Even in the flower stem that is removed from the mother plant, certain enzymes are mobilized to the wounded area where chemicals are released in order to try to seal the wound Tawar *et al.,* (2002) [15], Gaur *et al.* (2003) [3], Umrao *et al.* (2007) [16] and Chopde *et al.* (2013) [1] (Loub and Van Doorn 2004) [8]. Similar findings are reported by Munikrishnappa *et al.* (2014) [9] and Patel *et al.* (2013) [11].

Economics

A perusal of the data revealed that the highest net return (Rs. 548430/ha) and cost benefit ratio (1: 5.35) was obtained with treatment T_4 (GA_3 @ 200 ppm) followed by treatment T_5 (GA_3 @ 150 ppm) with net return (Rs. 518130/ha) and cost benefit ratio (1: 4.67). The treatment T_0 (control) recorded the lowest net return (Rs. 160085 /ha) and cost benefit ratio (1:1.41).

Table 1: Effect of Plant Growth Regulators on Plant height (cm), Plant Spread (cm), Number of Leaves/plant and Number of Branches/plant of China Aster

Treatment Symbol	Treatment Combinations	Plant Height (cm)				Plant Spread (cm)				Number of Leaves/plant				Number of Branches/plant			
		30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	120 DAS	120 DAS	30 DAS	60 DAS	90 DAS	120 DAS	30 DAS	60 DAS	90 DAS	120 DAS
T_0	Control	8.44	21.31	44.18	62.84	7.91	10.71	19.78	24.71	19.25	39.85	73.47	94.46	6.48	11.18	19.52	26.28
T_1	GA_3 @ 50 ppm	8.99	30.46	47.64	69.56	9.92	17.19	29.26	35.08	26.02	69.82	103.12	152.60	5.89	13.46	21.59	28.09
T_2	GA_3 @ 100 ppm	9.31	34.07	49.16	71.40	10.37	18.57	29.80	38.18	26.30	71.37	110.73	154.54	6.04	13.77	21.92	28.57
T_3	GA_3 @ 150 ppm	9.36	34.58	53.23	73.81	12.34	19.74	30.42	38.98	28.52	72.31	116.41	162.42	6.02	14.12	23.15	29.61
T_4	GA_3 @ 200 ppm	9.55	39.29	58.34	77.03	12.65	20.52	31.89	39.75	29.72	74.32	126.05	170.44	7.03	14.39	23.78	33.30
T_5	NAA @ 50 ppm	8.53	24.01	40.78	63.91	8.67	16.14	25.17	28.71	22.81	61.94	94.59	135.31	4.62	10.96	19.32	26.09
T_6	NAA @ 100 ppm	8.74	26.08	44.15	65.25	8.52	15.98	22.95	27.75	23.58	64.82	97.48	137.30	5.52	10.80	19.05	25.35
T_7	NAA @ 150 ppm	8.81	28.43	45.68	65.97	8.33	15.76	22.83	27.63	24.46	65.89	98.57	140.58	4.37	10.55	18.52	24.74
T_8	NAA @ 200 ppm	9.35	30.07	45.82	68.80	8.10	15.70	21.50	27.27	25.56	66.53	100.16	141.46	4.28	10.47	18.29	23.51
T_9	TRIACO @ 500 ppm	8.63	17.67	35.20	58.63	9.23	16.87	25.70	32.03	19.63	43.00	77.03	101.61	5.87	11.49	19.93	26.49
T_{10}	TRIACO @ 1000 ppm	7.67	16.11	34.95	55.71	9.28	16.81	27.25	33.05	20.81	45.38	80.78	103.81	5.38	12.44	20.44	26.78
T_{11}	TRIACO @ 1500 ppm	8.06	15.13	33.00	53.77	9.67	16.90	27.80	34.13	21.37	49.97	88.58	114.85	5.62	12.90	20.94	27.20
T_{12}	TRIACO@ 2000 ppm	7.45	13.43	32.36	53.43	9.73	17.03	29.09	34.44	21.06	46.59	84.39	107.03	5.11	13.13	21.23	27.93
-test		NS	S	S	S	NS	S	S	S	S	S	S	S	NS	S	S	S
SE(d)		-	0.739	0.954	1.174	-	0.655	0.874	1.092	1.910	1.618	1.842	2.067	-	0.613	0.803	1.046
C.D. at 5%		-	1.525	1.969	2.422	-	1.351	1.803	2.254	3.941	3.340	3.802	4.266	-	1.266	1.657	2.159

Table 2: Effect of Plant Growth regulators on Days to first flower bud initiation, Days to first and 50% flowering, Flower diameter (cm), Flower weight (g), Number of flower/plant, Flower yield/plant, yield/plot, yield/ha, Vase life of cut flower and Benefit cost ratio of China Aster.

Treatment Symbol	Treatment Combinations	Days to first flower bud initiation	Days to 50% bud initiation	Days to first flowering	Days to 50% flowering	Flower diameter (cm)	Flower weight (g)	Number of flowers/ plant	Flower yield/ plant (g)	Flower yield/ plot (g)	Flower yield/ hectare (t/h)	Vase life (days) of cut flowers at room temperature	Benefit Cost Ratio
T_0	Control	63.95	74.21	80.96	86.36	4.71	4.18	35.14	101.52	1194.01	4.42	8.31	1.41
T_1	GA_3 @ 50 ppm	54.33	64.90	70.37	75.53	6.42	5.99	64.76	302.89	3610.34	10.88	10.19	4.23
T_2	GA_3 @ 100 ppm	55.72	66.80	71.84	77.16	6.70	6.17	66.77	322.92	3850.61	11.53	9.97	4.46
T_3	GA_3 @ 150 ppm	57.72	68.27	73.69	78.29	6.88	6.34	68.29	341.68	4075.58	12.14	10.08	4.67
T_4	GA_3 @ 200 ppm	58.32	70.19	75.03	79.80	7.50	6.79	72.83	395.71	4723.79	13.87	10.25	5.35
T_5	NAA @ 50 ppm	57.54	71.61	77.08	82.75	5.91	5.86	63.30	291.29	3471.71	10.46	9.21	4.10
T_6	NAA @ 100 ppm	58.83	72.84	78.03	83.99	5.92	5.92	66.71	309.36	3688.44	11.04	9.02	4.06
T_7	NAA @ 150 ppm	61.02	73.59	79.34	84.40	6.19	5.79	62.86	283.58	3378.90	10.23	8.89	3.96
T_8	NAA @ 200 ppm	61.55	73.72	78.34	85.34	6.07	5.63	60.43	260.73	3104.35	9.54	8.77	3.63
T_9	TRIACO @ 500 ppm	53.91	62.81	67.71	72.84	5.20	4.90	51.85	185.86	2205.81	7.14	9.37	2.61
T_{10}	TRIACO @ 1000 ppm	53.29	63.48	68.99	73.86	4.96	5.15	56.65	218.19	2594.05	8.16	10.08	3.06
T_{11}	TRIACO @ 1500 ppm	51.75	60.69	65.94	70.62	4.97	5.33	58.56	235.21	2798.08	8.72	10.27	3.29
T_{12}	TRIACO@ 2000 ppm	52.85	61.92	66.44	71.24	4.77	4.98	54.85	203.52	2418.28	7.67	9.56	2.85
F-test		S	S	S	S	S	S	S	S	S	S	S	
SE(d)		1.442	1.865	2.231	2.258	0.386	0.461	1.000	2.517	2.882	0.966	0.514	
C.D. at 5%		2.977	3.849	4.604	4.660	0.798	0.952	2.064	5.194	5.948	1.994	1.060	

Conclusion

Based on the findings of the present experiment it is concluded that the treatment T_4 (GA_3 @ 200 ppm) was found to be the best treatment of plant growth regulator in terms of plant height, plant spread, number of leaves/plant number of branches/plant, yield/ha with higher benefit cost ratio. Minimum number of days to flower bud initiation and maximum vase life (9 days) was recorded in T_{11} (TRIACO @ 1500 ppm) in China aster.

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