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Influence of various concentrations of gibberellic acid (GA_3) and spraying frequencies on growth, yield and post-harvest parameters of China aster [*Callistephus chinensis* (L.) Nees.]

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Abstract
An experiment was conducted to study the effect of foliar application of GA_3 at three different concentrations, viz., 50, 100 and 150 ppm with two spray frequencies (twice and thrice) on three varieties of China aster, i.e., Shashank, Arka Archana and Arka Aadya. The study was conducted at the Department of Floriculture and Landscaping, College of Agriculture, O.U.A.T., Bhubaneswar during 2016-17 in order to establish the effect of foliar application of gibberellic acid (GA_3) on the growth, flowering, yield and shelf life of China aster. Plants of variety Arka Archana produced the highest leaf area and maximum flower stalk girth. However, variety Arka Aadya produced plants with maximum stem girth, flower diameter, fresh and dry weight of flower and duration of shelf life. Application of GA_3 @ 150 ppm sprayed twice resulted in maximum leaf area, stem girth and girth of flower stalk. GA_3 at 50 ppm concentration when applied thrice resulted in maximum flower diameter, maximum fresh weight and dry weight of flower. Thrice application of GA_3 at 100 ppm recorded the best results with respect to the shelf life of flowers. Interaction of varieties with treatments was found to be significant for most of the parameters except shelf life of flowers.

Keywords: GA_3, China aster, spray frequency, shelf life

Introduction
Flowers are intricately entwined in the social fabric of our country and no function is complete without flowers. With changing life styles and increased urban affluence, flower growing has assumed a definite commercial status in recent times. A popular member of Asteraceae family, China aster (*Callistephus chinensis* L. Nees.) is native to China. The genus *Callistephus* derived its name from two Greek words '*kalistos*' and '*stephos*' meaning 'most beautiful' and 'a crown', respectively. Among annual flower crops, China aster ranks next only to chrysanthemum and marigold (Sheela, 2008) [9]. It is a very popular annual flower crop and is mainly cultivated for the production of cut flowers, loose flowers, as pot plant and for bedding plant purposes in landscape. Growth regulating chemicals are applied when a desirable effect cannot be achieved by manipulation of the plant environment. Synthetic growth regulating chemicals are becoming extremely important and valuable in the floriculture for manipulating the growth and flowering of many commercial flower crops and ornamental plants. Gibberellins play an important role in the physiological processes of plant life cycle like stem elongation, germination, breaking dormancy, flowering, sex expression, enzyme induction, leaf and fruit senescence, flowering and quality of produce. Since gibberellic acid (GA_3) regulates growth, applications at very low concentrations can have a profound effect while too much will have detrimental effect. The present experiment was conducted in order to find the effect of gibberellin on different varieties of China aster.

Materials and Methods
The present research was carried out at Department of Floriculture and Landscaping, College of Agriculture, O.U.A.T., Bhubaneswar, Odisha considering three varieties of china aster, viz. Shashank, Arka Archana and Arka Aadya and two spray frequencies of GA_3, i.e., twice (30 and 40 days after transplanting) and thrice (30, 40 and 50 days after transplanting). The treatments included in the study were T_1 - Control, T_2 - Two sprays of 50 ppm GA_3, T_3 - Three sprays of 50 ppm GA_3, T_4 - Two sprays of 100 ppm GA_3, T_5 - Three sprays of 100 ppm GA_3, T_6 - Two

sprays of 150 ppm GA_3 and T_7 - Three sprays of 150 ppm GA_3. The study was conducted by planting four weeks old seedlings in pots with media mixture of soil, FYM and sand in 2:1:$^1/_2$ ratio and the plants were provided the recommended dose of fertilizers in equal quantities invariable of treatments. The experiment was laid out in Factorial Completely Randomized Design with all the three varieties replicated thrice.

Results and Discussion

From Table 1, it is clear that different treatment combinations had significant influence on various characters considered in the investigation. It was observed that plants treated with T_6 (two sprays of 150 ppm GA_3) recorded maximum leaf area (44.14 cm^2) and stem girth (37.70 mm) as compared to T_1 (control) which recorded the minimum results for leaf area and stem girth. Increase in leaf area and stem girth may be due to the fact that GA_3 is known to influence cell enlargement and cell division. The results are in conformity with the findings of Sharifuzzaman *et al*. (2011) [7] in chrysanthemum, Kumar *et al*. (2003) [5] in China aster; and Choudhari (2012) [1] in daisy. Among the floral characters, plants treated with T_6 (two sprays of 150 ppm GA_3) recorded maximum flower stalk girth (5.73 mm) as compared to T_1 (control) which recorded the minimum value for flower stalk girth. Cell division as well as cell enlargement is affected by GA_3. This may be the cause of increase in the girth of flower stalk. It may also be due to better overall vegetative growth of the plants. Similar findings have been reported by Dalal *et al*. (2009) [2] in gerbera and Gowda (1980) [4] in rose. Maximum flower diameter (6.31 cm) was observed in T_3 (three sprays of 50 ppm GA_3) while minimum flower diameter was recorded in T_1 (control). Active cell elongation in the flower might be the reason of increase in flower diameter. GA_3 is also known to be the component of florigen which is required for formation of flowers in the plant system and rapid mobilization and accumulation of metabolites which influence the floral morphogenesis resulting in bigger sized flowers. The results are in accordance with the findings of Kumar *et al*. (2003) [5], Doddagoudar *et al*. (2004) [3]; and Sharma and Joshi (2015) [8] in China aster. Maximum fresh weight (7.00 g) and dry weight (2.17 g) was observed under T_3 (three sprays of 50 ppm GA_3). However, minimum fresh weight and dry weight was recorded under T_6 (two sprays of 150 ppm GA_3). Increase in fresh weight and dry weight may be due to increased flower size and better overall plant growth, thus resulting in a net increase in the photosynthates. Similar findings have been reported by Nagarjuna *et al*. (1988) [6], Sainath *et al*. (2014) [11] in chrysanthemum; and Swaroop *et al*. (2007) [12] in African marigold. Plants treated with T_5 (three sprays of 100 ppm GA_3) recorded longest shelf life (67.67 hours) while it was minimum under T_1 (control). Enhancement of the shelf life might be due to the overall modified effect on the vegetative and reproductive growth of the plant. Similar findings have been reported by Vijayakumar *et al*. (2017) [10] in China aster.

Among the different varieties included in the study, Arka Archana (V_2) recorded maximum leaf area (45.28 cm^2) and maximum flower stalk girth (5.91 mm) while maximum stem girth (4.74 cm), flower diameter (7 cm), fresh weight (7.46 g), dry weight (1.85 g) and longest shelf life (70.44 hours) was observed in variety Arka Aadya (V_3). These differences may be due to the diversity in the genotype of the varieties.

Interaction between the varieties and GA_3 treatments showed that maximum leaf area (49.21 cm^2) and maximum flower stalk girth (6.69 mm) was obtained in variety Arka Archana when the plants were sprayed with T_6 - Two sprays of 150 ppm GA_3 (V_2T_6) while maximum flower diameter (7.24 cm) and longest shelf life (71.40 hours) was recorded in variety Arka Aadya when treated with T_5 - Three sprays of 100 ppm GA_3 (V_3T_5). Arka Aadya when treated with T_3 - Three sprays of 50 ppm GA_3 (V_3T_3) recorded maximum fresh weight (8.09 g) and dry weight (2.14 g) while Arka Aadya treated with T_6 - Two sprays of 150 ppm GA_3 (V_3T_6) recorded maximum stem girth (5.10 cm).

Table 1: Influence of different levels of GA_3 and spraying frequencies on various attributes of China aster

	Leaf area (cm^2)	Stem girth (cm)	Flower diameter (cm)	Girth of flower stalk (mm)	Fresh weight of flower (g)	Dry weight of flower (g)	Shelf life of flower (hours)
Variety (V)							
V_1	33.63	2.37	5.23	4.83	4.93	1.05	62.86
V_2	45.28	3.32	5.93	5.91	6.69	1.49	66.42
V_3	40.55	4.74	7.00	4.57	7.46	1.85	70.44
SE (m) ±	0.13	0.02	0.03	0.02	0.04	0.02	0.15
CD at 5%	0.37	0.07	0.09	0.07	0.10	0.04	0.43
Treatment (T)							
T_1	36.39	3.15	5.76	4.48	6.32	1.37	65.63
T_2	36.93	3.27	5.95	4.69	6.69	1.55	65.87
T_3	38.21	3.38	6.31	4.83	7.00	1.85	66.89
T_4	42.78	3.47	6.24	5.13	6.45	1.66	67.43
T_5	40.81	3.79	6.25	5.47	6.21	1.46	67.67
T_6	44.14	3.81	5.94	5.73	5.92	1.19	66.30
T_7	39.47	3.48	5.92	5.39	5.94	1.15	66.24
SE (m) ±	0.20	0.04	0.05	0.04	0.05	0.02	0.23
CD at 5%	0.56	0.10	0.14	0.11	0.15	0.07	0.66
Variety × Treatment (V × T)							
V_1T_1	30.12	1.99	5.00	4.22	5.18	1.07	62.00
V_1T_2	30.80	2.18	5.20	4.45	5.34	1.16	62.20
V_1T_3	31.92	2.20	5.42	4.60	5.74	1.44	63.70

V_1T_4	36.42	2.49	5.61	4.97	4.89	1.02	63.10
V_1T_5	32.71	2.80	5.34	5.58	4.68	0.91	64.00
V_1T_6	38.61	2.60	5.06	5.22	4.29	0.87	62.30
V_1T_7	34.82	2.35	5.01	4.76	4.44	0.86	62.70
V_2T_1	41.63	3.07	5.62	5.35	6.44	1.32	65.10
V_2T_2	42.00	3.10	5.86	5.54	6.87	1.46	65.40
V_2T_3	42.82	3.24	6.36	5.60	7.18	1.96	66.67
V_2T_4	48.80	3.13	6.03	5.78	7.04	1.88	68.30
V_2T_5	47.90	3.57	6.18	6.04	6.66	1.63	67.60
V_2T_6	49.21	3.73	5.71	6.69	6.32	1.08	66.10
V_2T_7	44.60	3.43	5.74	6.38	6.29	1.11	65.80
V_3T_1	37.41	4.39	6.66	3.88	7.32	1.73	69.80
V_3T_2	38.00	4.54	6.79	4.09	7.85	2.03	70.00
V_3T_3	39.90	4.70	7.14	4.28	8.09	2.14	70.30
V_3T_4	43.12	4.79	7.09	4.64	7.44	2.08	70.90
V_3T_5	41.81	5.00	7.24	4.81	7.29	1.85	71.40
V_3T_6	44.60	5.10	7.06	5.26	7.14	1.63	70.50
V_3T_7	39.00	4.66	7.00	5.02	7.08	1.48	70.21
SE (m) ±	0.34	0.06	0.09	0.06	0.09	0.04	0.40
CD at 5%	0.97	0.17	0.24	0.18	0.27	0.11	1.14

N.B. V_1 - Shashank T_1 - Control (water spray) T_5 -GA_3 @ 100 ppm (thrice) V_2 - Arka Archana T_2 - GA_3 @ 50 ppm (twice) T_6 -GA_3 @ 150 ppm (twice) V_3 - Arka Aadya T_3 - GA_3 @ 50 ppm (thrice) T_7 -GA_3 @ 150 ppm (thrice) T_4 - GA_3 @ 100 ppm (twice

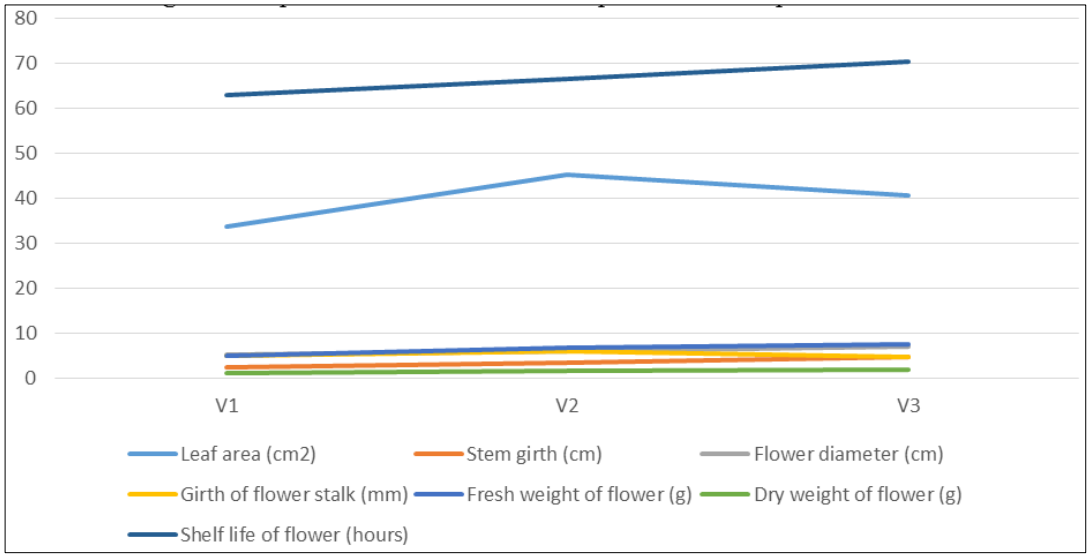

Fig 1: Comparison of varieties with respect to various parameters

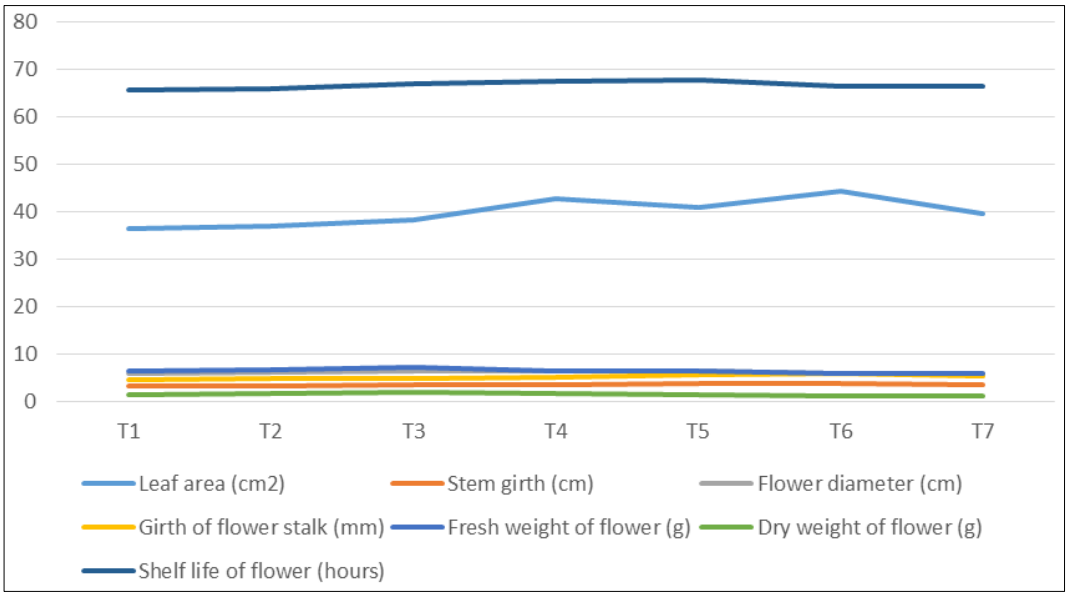

Fig 2: Comparison of treatments with respect to various parameters

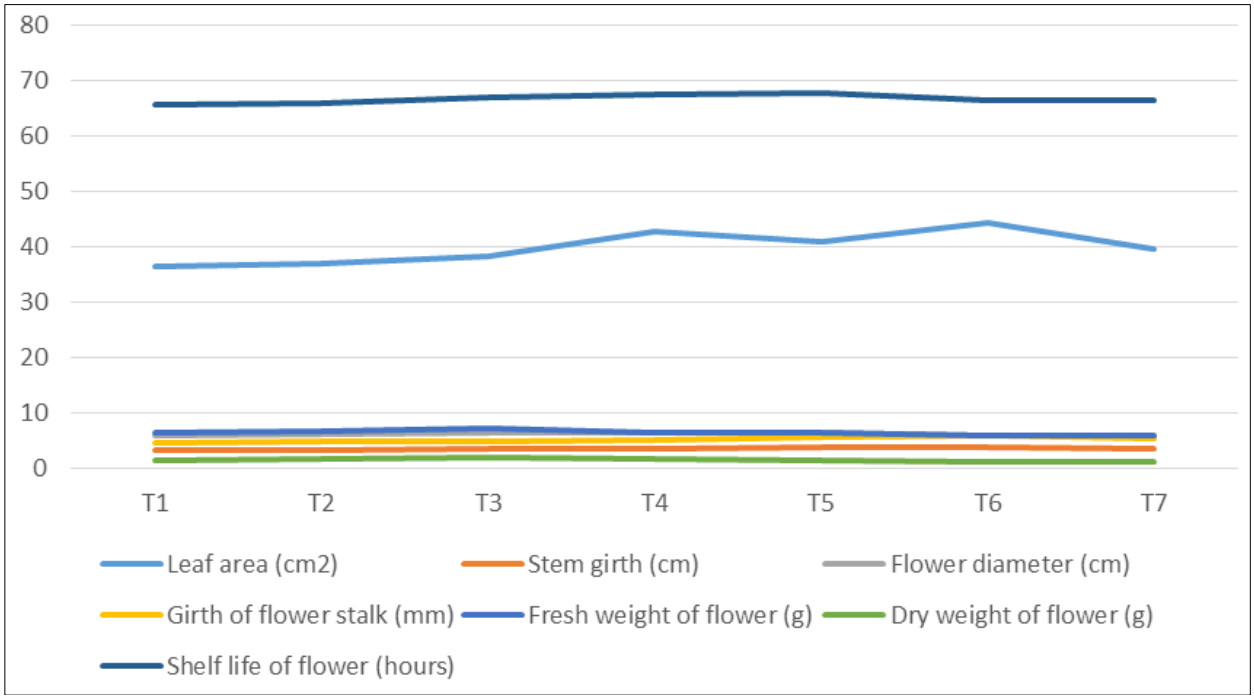

Fig 3: Interaction of varieties and treatments with respect to various parameters

Conclusion

From the present investigation, it can be concluded that floral attributes like flower diameter, fresh weight and dry weight were found to be best under the application of GA_3 @ 50 ppm sprayed thrice whereas application of GA_3 @ 100 ppm (thrice) gave the best results with respect to the shelf life of the flowers. However, foliar application of GA_3 @ 150 ppm sprayed twice gave superior outcomes pertaining to leaf area, stem girth and flower stalk girth as compared to the control.

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