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Effect of Plant Growth Regulators on Different Cultivars of China Aster (*Callistephus chinensis* L.) in Hilly Terrain

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present study was conducted to investigate the effect of varieties and growth regulators on seed yield and quality parameters in the hilly terrain. The experiment was laid in a factorial randomised block design (RBD). The study was conducted at the Kakhali Research Farm of DKSGACA, Eternal University, Baru Sahib, Himachal Pradesh, during *kharif* season of 2023.

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Twenty treatments were constituted using two factors, namely varieties *viz.,* Arka Kamini and Arka Archana, and different levels of plant growth regulators *viz.,* GA_3 (100, 150 and 200 ppm), NAA (25, 50 and 75 ppm) and CCC (500, 750 and 1000 ppm) with control. The observations for the seed yield and quality parameters were observed and analyzed *i.e.,* the number of seeds per flower head (g), seed yield per hectare (g), test weight (g), germination percentage (%), speed of germination (days), germination uniformity and seedling length (cm). The number of seed flower head^{-1}(166.33), seed yield ha^{-1} (131.41 kg) and germination percentage (81.0 %) were found to be maximum in cv. Arka Kamini, whereas for test weight (24.80 g) and Seedling length (4.60 cm) cv. Arka Archana was found to be best. In case growth regulators, GA_3 at 200 ppm was found to be best for seed yield ha^{-1}, test weight and germination percentage, NAA at 100 ppm for the number of seed flower head^{-1} and CCC at 500 ppm for seedling length. Whereas, the number of seed flower head^{-1}, seed yield ha^{-1}, test weight and germination percentage were found to be maximum in the interactive effect of Arka Kamini and GA_3 at 200 ppm. For the study, it was observed that all seed yield and quality parameters of China aster except the speed of germination and germination uniformity were significantly influenced by the varieties, plant growth regulators and their interactions. This study will directly help the seed industry and flower growers by enhancing seed production and quality and improving their economic condition.

Keywords: China aster; Plant growth regulators; Gibberellic acid; Naphthalene Acetic Acid; cycocel; seed yield; seed quality.

1. INTRODUCTION

China's aster, botanically known as *Callistephus chinensis* L., is a well-known and lucrative annual flowering plant from the Asteraceae family. In India, It is traditionally produced for its loose flowers, cut flowers, landscaping, floral garlands, decorations etc. Flowers are solitary, with the predominant flower colors being pink, blue, and white. China aster is highly liked by farmers because, during a specific season or event, the flower may command a very good price when supply matches demand. Small and marginal farmers tend to like it more because of the relatively easy it is to grow in an open environment [1,2]. In India, China aster is mostly is produced in Karnataka, Maharashtra, Andhra Pradesh, Tamil Nadu, and West Bengal in the winter season, whereas in hills of Himachal Pradesh and Uttarakhand, it is grown as offseason crop during February to July [3]. Although varietal features mostly influence cut flower quality, climatic, regional, and nutritional parameters also have a significant role. The physiological processes of plants can be altered to minimize the need for fertilizers. Exogenous use of plant growth regulators has transformed Horticulture, particularly Floriculture industry globally, with major implications for cut flower production and post-harvest management. These regulators, which include promoters like Gibberellins and NAA and inhibitors like Cycocel, are critical in floriculture for increasing productivity and quality. Recent scientific research emphasizes their importance in improving plant growth, productivity, floral quality, seed yield and quality [4,5,6,7,8,9]. By considering the above points, the present study was carried out to increase the seed quantity and quality of china aster in cv. Arka Kamini and Arka Archana using plant growth regulators in hilly terrain of Himachal Pradesh.

2. MATERIALS AND METHODS

The present investigation was carried out in Kakhali Research Farm of Dr. Khem Singh Gill Akal College of Agriculture, Eternal University, Baru Sahib, Sirmour, Himachal Pradesh (India) during the *Kharif* season of 2023. The experiment geographical area lies on latitudes 30.7537° N and longitudes 77.2965° E of mid hills of Himachal Pradesh (India) in an altitude of 1067 m from above mean sea level. The research trial was laid out in factorial randomized block design with three replications. The experiment includes twenty treatments combinations, which were constituted using two factors. First factor includes two varieties of China aster *viz.,* Arka Kamini (V_1) and Arka Archana (V_2), while the second includes ten levels of plant growth regulators *i.e.*, G_0 (Control), G_1 (GA_3 at 100 ppm),G_2 (GA_3 at 150 ppm GA_3 at 200 ppm), G_3 (NAA at 100 ppm),G_4 (NAA at 25 ppm),G_5 (NAA at 50 ppm),G_6 (NAA at 75 ppm),G_7 (CCC at 500 ppm),G_8 (CCC at 750 ppm) and G_9 (CCC at 1000 ppm). The seeds of cv. Arka Kamini and Arka Archana were sown in the nursery, and one month old seedlings of China aster are planted in the main field. After that the seedlings were planted in the experimental field with a spacing of 40 cm plant to plant and 40 cm row to row a plot of 4 m^2 of area. The two foliar applications of plant growth regulators were done, the first spray was done after one month of planting and the second was done after fifteen days from the first application. The data were recorded for the seed yield and quality parameters *i.e.*, no. of seeds per flower head (g), seed yield per hectare (g), test weight (g), germination percentage (%), speed of germination, germination uniformity and seedling length (cm). The data were measured and recorded as per standard procedure. The plant parameters were recorded, by selecting the five random plants from each replication of a treatment and significant variations were recorded from the plant. The plants had undergone various intercultural operations and plant protection measures required for better plant production during the course of investigation. Further, the analysis of variance (ANOVA) was done through OPSTAT software [10].

3. RESULTS AND DISCUSSION

The treatments of plant growth regulators and varieties significantly affected yield and quality parameters of China aster except the speed of germination and germination uniformity.

3.1 Number of Seed flower Head^{-1} (g)

In present study the result exhibited that, the maximum number of seed per flower head was found in treatment V_1 (162.53) and lowest was found in V_2 (154.57) (Table 1). Whereas, In case of PGR's the highest number of seed per flower head was found in treatment G_6 (166.83) and lowest in G_2 (148.67). Among the interactions, the highest number of seed per flower head was found in V_1G_3 (169.33) and lowest in V_2G_1 (144.33). This might be the result of the plants treated with gibberellic acid and NAA growing profusely and producing more photosynthetic material. This could have led to the production of high-quality flowers and an increase in the quantity of seeds. The findings are in line with the results obtained by [11] in China aster and [12] in French marigold.

3.2 Seed Yield Hectare^{-1} (Kg)

The maximum seed yield per hectare was observed in V_1 (131.41 kg) and minimum was recorded in treatment V_2 (127.75 kg). Whereas, In case of PGR's the highest seed yield per hectare was observed treatment G_3 (142.02 kg) and lowest in G_8 (118.33 kg). Among the interactions, the maximum seed yield per hectare was recorded in V_1G_3 (155.34 kg) and minimum were observed in V_2G_8 (116.39 kg) (Table 2). The variation in seed quality parameters between the treatments might be closely related to the genetic makeup of the cultivar. The higher seed yield hectare in China aster was recorded in plants sprayed with gibberellic acid. This might be due to maximum vegetative growth which helped in improving the protein synthesis and resulted in production of better quality flowers as well as seeds. The findings are closely aligned with the study of [12] in marigold, [13] in China aster and [14] in china aster.

Table 1. Effect of different varieties and plant growth regulators on number of seeds per head of China aster

Treatments	Arka Kamini (V_1)	Arka Archana (V_2)	PGR Mean
G_0	162.67	159.00	160.83
G_1	153.00	144.33	148.67
G_2	161.67	148.33	155.00
G_3	169.33	158.00	163.67
G_4	163.67	158.33	161.00
G_5	159.00	159.33	159.17
G_6	166.33	167.33	166.83
G_7	160.00	150.67	155.33
G_8	162.00	147.67	154.83
G_9	167.67	152.67	160.17
Variety Mean	162.53	154.57	
Factors		C.D. at 5 %	
Variety (V)		2.19	
PGR (G)		4.89	
Variety X PGR		6.91	

Table 2. Effect of different varieties and plant growth regulators on Seed Yield Hectare^{-1} of China aster

Treatments	Arka Kamini (V_1)	Arka Archana (V_2)	PGR Mean
G_0	131.79	128.26	130.02
G_1	136.35	118.10	127.23
G_2	115.69	124.05	119.87
G_3	155.34	128.70	142.02
G_4	128.08	130.28	129.18
G_5	143.27	132.59	137.93
G_6	132.42	145.98	139.20
G_7	116.60	129.52	123.06
G_8	120.26	116.39	118.33
G_9	134.30	123.63	128.97
Variety Mean	131.41	127.75	
Factors		C.D. at 5 %	
Variety (V)		3.01	
PGR (G)		6.74	
Variety X PGR		9.53	

Table 3. Effect of different varieties and plant growth regulators on test weight of China aster

Treatments	Arka Kamini (V_1)	Arka Archana (V_2)	PGR Mean
G_0	24.00	23.87	23.93
G_1	26.40	24.27	25.33
G_2	21.20	24.80	23.00
G_3	27.20	24.13	25.67
G_4	23.20	24.40	23.80
G_5	26.67	24.67	25.67
G_6	23.60	25.87	24.73
G_7	21.60	25.47	23.53
G_8	22.00	23.33	22.67
G_9	23.73	24.00	23.87
Variety Mean	23.96	24.48	
Factors		C.D. at 5 %	
Variety (V)		0.49	
PGR (G)		1.10	
Variety X PGR		1.55	

3.3 Test Weight (g)

The highest test weight was found in V_2 (24.48 g) and lowest was found in V_1 (23.96 g). Whereas, In case of PGR's the highest test weight was found in treatment G_3 (25.67 g) and lowest in G_8 (22.67 g). Among the interactions, the highest test weight was found in V_1G_3 (27.20 g) and lowest in V_1G_2 (21.20 g) (Table 3). The genotypes may vary in seed weight due to their genotypic behavior whereas growing conditions, biotic and abiotic stresses may also responsible for the variation in test weight. A significant increment in test weight had observed after treating with Gibberellic acid in China aster. This could be the reason for the greater test weight of the seed after gibberellic acid treatment. The outcomes of this study closely align with the findings of [15] in China aster, [12] in French marigold.

3.4 Germination Percentage (%) and Speed of Germination

The highest germination percentage and speed of germination were found in treatment V_1 (81.0 % & 4.12) and lowest were found in V_2 (75.0 % & 4.0). Whereas, In case of PGR's the highest germination percentage and speed of germination were recorded at G_3 (86.50 %) and $G_{2\ \&\ 5}$ (4.23), while lowest were observed in G_1 (72 %) and G_6 (3.88), respectively. Among the interactions, the maximum germination percentage and speed of germination were found in V_1G_3 (88.0 %) and V_1G_9 (4.34), respectively. Whereas, lowest germination percentage and speed of germination were observed in V_2G_1 (64.0 %) and V_2G_0 (3.68) (Tables 4 and 5). Application of gibberellic acid had significantly increase the germination percentage and speed of seed in China aster. This may be result of arise in the test weight of seed which might have provided sufficient food reserves to resume embryo macromolecules to be used in growth promoting processes. The results obtained in this investigation are closely aligned with the findings of [16] in annual chrysanthemum and [17] in china aster.

3.5 Germination Uniformity

Germination uniformity was recorded maximum in V_2 (0.59) and minimum was observed in treatment V_1 (0.56). Whereas, In case of PGR's the highest germination uniformity was found at G_8 (0.62) and lowest (0.52) at G_3 and G_4. Among the interactions, the highest germination uniformity was found in V_1G_2 (0.63) and lowest in V_1G_6 (0.50) (Table 6). Variation in germination uniformity among the different treatments of growth regulators and varieties might be caused due various factors such as light, moisture, temperature and genetic makeup of the plant. Similar results were also observed by [18] and [19] in China aster.

Table 4. Effect of different varieties and plant growth regulators on germination percentage of China aster

Treatments	Arka Kamini (V_1)	Arka Archana (V_2)	PGR Mean
G_0	84.00	66.00	75.00
G_1	80.00	64.00	72.00
G_2	87.00	76.00	81.50
G_3	88.00	85.00	86.50
G_4	65.00	72.00	68.50
G_5	86.00	75.00	80.50
G_6	81.00	82.00	81.50
G_7	78.00	79.00	78.50
G_8	83.00	77.00	80.00
G_9	74.00	73.00	73.50
Variety Mean	80.60	74.90	
Factors		C.D. at 5 %	
Variety (V)		1.21	
PGR (G)		2.71	
Variety X PGR		3.84	

Table 5. Effect of different varieties and plant growth regulators on speed of germination of China aster

Treatments	Arka Kamini (V_1)	Arka Archana (V_2)	PGR Mean
G_0	4.09	3.68	3.89
G_1	4.20	3.94	4.07
G_2	4.33	4.13	4.23
G_3	4.09	4.17	4.13
G_4	3.94	4.01	3.98
G_5	4.11	4.35	4.23
G_6	4.03	3.74	3.88
G_7	3.98	4.11	4.05
G_8	4.07	4.03	4.05
G_9	4.34	3.85	4.10
Variety Mean	4.12	4.00	
Factors		C.D. at 5 %	
Variety (V)		0.11	
PGR (G)		NS	
Variety X PGR		NS	

Table 6. Effect of different varieties and plant growth regulators on germination uniformity of China aster

Treatments	Arka Kamini (V_1)	Arka Archana (V_2)	PGR Mean
G_0	0.60	0.55	0.58
G_1	0.56	0.55	0.56
G_2	0.63	0.55	0.59
G_3	0.49	0.55	0.52
G_4	0.53	0.51	0.52
G_5	0.59	0.58	0.58
G_6	0.50	0.60	0.55
G_7	0.58	0.63	0.61
G_8	0.56	0.67	0.62
G_9	0.52	0.67	0.60
Variety Mean	0.56	0.59	
Factors		C.D. at 5 %	
Variety (V)		NS	
PGR (G)		NS	
Variety X PGR		NS	

Table 7. Effect of different varieties and plant growth regulators on seedling length of China aster

Treatments	Arka Kamini (V_1)	Arka Archana (V_2)	PGR Mean
G_0	4.30	5.21	4.75
G_1	4.31	4.35	4.33
G_2	3.81	3.95	3.88
G_3	3.94	4.54	4.24
G_4	4.22	5.04	4.63
G_5	4.67	4.32	4.50
G_6	5.22	4.80	5.01
G_7	5.47	5.30	5.39
G_8	4.35	4.16	4.25
G_9	4.78	4.94	4.86
Variety Mean	4.51	4.66	
Factors		C.D. at 5 %	
Variety (V)		0.05	
PGR (G)		0.11	
Variety X PGR		0.15	

3.6 Seedling Length (cm)

The present study result showed that, the highest seedling length was found in V_2 (4.66 cm) and lowest was found in V_1 (4.51 cm). Whereas, In case of PGR's the highest seedling length was found in treatment G_7 (5.39 cm) and lowest in G_2 (3.88 cm). Among the interactions, the highest seedling length was found in V_1G_7 (5.47 cm) and lowest in V_1G_2 (3.81 cm) (Table 7). Variation in seedling length among the different treatments of growth regulators and varieties might be caused due various factors such as environmental factors and genetic makeup of the plant. Level of gibberellic acid in seed may also responsible for the variation, early germination is also associated with the seedling length of the seed. Similar results were also observed by the [18] and [19] in China aster.

4. CONCLUSION

From the findings of the current experiment, it can be concluded that applications of varieties, plant growth regulators and their interactions have a significant effect on all the seed yield and quality parameters of China aster except the speed of germination and germination uniformity. Arka Kamini could be selected for the seed yield traits, whereas Arka Archana is best suited for seed quality traits of China aster. Among the plant growth regulators, GA_3 at 200 ppm, NAA at 100 ppm and CCC at 500 ppm are best suited for foliar application. Arka Kamini in combination with GA_3 at 200 ppm, is best suited for application in China aster for increasing seed yield and quality parameters. This study will directly help the seed industry and flower growers by enhancing seed production and quality and will improving their economic condition.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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