



Plant Archives

Journal homepage: <http://www.plantarchives.org>

DOI Url : <https://doi.org/10.51470/PLANTARCHIVES.2026.v26.supplement-1.377>

INFLUENCE OF SPACING AND FERTILIZER ON GROWTH, FLOWERING AND YIELD IN CHINA ASTER (*CALLISTEPHUS CHINENSIS* L. NEES) VAR. KRISHNA PRABHA CHINMAYA

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(Date of Receiving : 13-10-2025; Date of Acceptance : 27-12-2025)

ABSTRACT

A field experiment was conducted during 2024-25 at the Floriculture Block, Seed Unit, University of Horticultural Sciences, Bagalkot, to investigate the influence of spacing and fertilizer levels on growth, flowering and yield in China aster var. Krishna Prabha Chinmaya. The experiment was laid out in a Factorial Randomized Complete Block Design (FRCBD), comprising three spacing levels (S_1 : 30 × 30 cm, S_2 : 45 × 30 cm and S_3 : 45 × 45 cm) and three fertilizer levels (F_1 : 180:120:60, F_2 : 205:135:70 and F_3 : 225:150:75 kg NPK/ha) with three replications, resulting in nine treatment combinations. Spacing significantly influenced crop performance, with the widest spacing (S_3) recording maximum plant spread (N–S: 50.90 cm and E–W: 50.58 cm), highest number of flowers per plant (43.78), largest flower diameter (7.72 cm) and highest flower yield per plant (225.01 g), indicating reduced interplant competition and more efficient use of light, nutrients and space. Fertilizer levels also exerted a pronounced effect where highest fertilizer dose, (F_3) resulted in superior plant height (43.34 cm), greater plant spread (N–S: 50.11 cm and E–W: 49.48 cm), higher number of primary (14.10) and secondary branches (17.27), maximum number of flowers per plant (43.33), highest flower yield per plant (210.99 g) and larger flower diameter (7.07 cm), emphasizing the importance of balanced nutrient supply. The interaction effect further revealed that the combination S_3F_3 consistently produced the best overall performance with superior growth, flowering attributes and the highest flower yield per plant, demonstrating that optimum plant spacing coupled with adequate nutrient availability is essential for maximizing productivity and flower quality in China aster under the experimental conditions.

Keywords: China aster, *Callistephus chinensis* (L.) Nees, spacing, fertilizer, growth, flowering.

Introduction

China aster [*Callistephus chinensis* (L.) Nees] is a commercially significant ornamental belonging to Asteraceae, valued globally for its diverse flower forms and colours. The genus name originates from the Greek words *kalistos* and *stephos*, meaning most

beautiful and a crown (Navalinskien *et al.*, 2005). China aster is a half-hardy annual widely valued for its wide spectrum of flower forms and colours including violet, purple, magenta pink and white (Kumari *et al.*, 2017). It is ranked third among annual flowers after chrysanthemum and marigold (Sheela, 2008). The crop symbolizes purity and love and is widely used in cut

flower arrangements, bouquets, garlands, landscaping and pot culture (Bhargav *et al.*, 2016). In India, it occupies about 3,500 ha, with major production in Karnataka, Tamil Nadu, Andhra Pradesh, Maharashtra and West Bengal (Sarkar *et al.*, 2020). Karnataka alone produces 1,448 MT annually from 207 ha, with a productivity of 7.01 t/ha (Anonymous, 2020).

Growth and flowering in China aster are strongly influenced by planting geometry and nutrient management. Nitrogen, phosphorus and potassium are vital for vegetative growth, flower initiation and quality, with nitrogen supporting leaf and stem development, phosphorus enhancing root growth, energy transfer and flowering, and potassium regulating water balance and improving flower size and colour (Chaudhary, 2018). Proper plant spacing improves light penetration, air circulation and root expansion, affecting plant height, branching, flower diameter and yield. Wider spacing promotes better plant spread and flower size, while closer spacing increases flower number per unit area. Optimizing spacing enhances productivity, quality and commercial performance (Kumar *et al.*, 2014).

Considering the importance of ideal planting geometry and nutrient balance in determining crop performance, the present investigation titled Influence of spacing and fertilizer levels on growth and flowering in China aster var. Krishna Prabha Chinmaya was undertaken to evaluate their effects on growth attributes and flowering behaviour of the crop for commercial cultivation.

Material and Methods

A field experiment was conducted during 2024-25 at the Seed Unit, College of Horticulture, University of Horticultural Sciences, Bagalkot, Karnataka, India. The experiment aimed to study the influence of spacing and fertilizer levels on growth and flowering of China aster [*Callistephus chinensis* (L.) Nees] var. Krishna Prabha Chinmaya. The soil at the experimental site was red loamy and irrigation was provided through a drip system as per requirement.

The treatments comprised three levels of spacing- S_1 : 30 × 30 cm, S_2 : 45 × 30 cm and S_3 : 45 × 45 cm and three levels of fertilizer- F_1 : 180:120:60 kg NPK/ha, F_2 : 205:135:70 kg NPK/ha and F_3 : 225:150:75 kg NPK/ha, forming nine treatment combinations. The experiment was laid out in a Factorial Randomized Complete Block Design (FRCBD) with three replications. Each gross plot measured 2.7 × 2.7 m and five randomly selected plants per plot were tagged for recording observations.

Nitrogen, phosphorus and potassium were applied in the form of urea, single super phosphate and muriate of potash, respectively. Half of the nitrogen along with the full dose of phosphorus and potassium was applied at transplanting around each plant in a circular band, while the remaining nitrogen was top-dressed 30 days after transplanting using the ring method. Other cultural operations, including weeding and plant protection were carried out. Gap filling was done within seven days of transplanting to maintain uniform plant stand.

Growth parameters were recorded on plant height (cm), plant spread in North–South and East–West directions (cm) and number of primary and secondary branches per plant. Flowering traits recorded were days to flower initiation, days to 50 per cent flowering, flower diameter (cm), number of flowers per plant and flower yield per plant (g). Observations were recorded at 30 and 60 days after transplanting, while flowering parameters were recorded at the onset and peak of flowering. Data collected were subjected to analysis of variance (ANOVA) and treatment means were compared using the method of Panse and Sukhatme (1967) at $P = 0.05$ level of significance.

Result and Discussion

Growth Parameters

Plant height (cm)

Plant height of China aster varied significantly under different spacing and fertilizer treatments at both 30 and 60 DAT (Table 1). Closer spacing (S_1 : 30 × 30 cm) consistently resulted in taller plants (17.77 and 43.77 cm at 30 and 60 DAT, respectively) compared to the widest spacing S_3 (45 × 45 cm), which recorded 13.69 and 37.63 cm, respectively. The enhanced vertical growth under closer spacing is likely due to competition for light, stimulating elongation, consistent with Bhargav *et al.* (2016) and Nigam *et al.* (2024) in China aster.

Fertilizer levels also had a marked effect. The highest dose (F_3 : 225:150:75 NPK kg/ha) produced the tallest plants at 30 and 60 DAT (17.43 and 43.34 cm), while the lowest dose (F_1 : 180:120:60 NPK kg/ha) resulted in reduced height (13.99 and 38.17 cm), indicating that nutrient availability strongly influences vegetative growth, as reported by Maheta *et al.* (2016) and Pooja *et al.* (2016) in China aster.

The interaction between spacing and fertilizer was significant, with the S_1F_3 combination producing the tallest plants (20.20 and 46.70 cm at 30 and 60 DAT, respectively). This demonstrates that maximum growth is achieved when plant density and nutrient supply are

optimized, corroborating observations in French marigold (Pratheeksha *et al.*, 2024) and Daisy (Gowtham *et al.*, 2025).

Table 1 : Influence of spacing, fertilizer and their interaction on plant height (cm) at different stages of crop growth in China aster var. Krishna Prabha Chinmaya

Spacing (S)	Plant height (cm)							
	30 DAT				60 DAT			
	Fertilizer (F)				Fertilizer (F)			
	F ₁	F ₂	F ₃	Mean	F ₁	F ₂	F ₃	Mean
S ₁ - 30 x 30 cm	16.30	16.80	20.20	17.77	41.70	42.90	46.70	43.77
S ₂ - 45 x 30 cm	15.20	16.10	16.50	15.93	40.30	41.50	42.73	41.51
S ₃ - 45 x 45 cm	10.47	15.00	15.60	13.69	32.50	39.80	40.60	37.63
Mean	13.99	15.97	17.43		38.17	41.40	43.34	
For comparing the means of	S.Em±			C.D @ 5%	S.Em±			C.D @ 5%
Spacing (S)	0.35			1.04	0.65			1.95
Fertilizer (F)	0.35			1.04	0.65			1.95
S X F	0.60			1.80	1.13			3.37

Fertilizer (F): F₁ - 180:120:60 NPK kg/ha, F₂ - 205:135:70 NPK kg/ha, F₃ - 225:150:75 NPK kg/ha; DAT: Days after transplanting

Plant spread (cm)

Plant spread in both North-South and East-West directions was influenced significantly by spacing, fertilizer and their interaction (Tables 2). The widest spacing (S₃: 45 × 45 cm) consistently resulted in the greatest spread at 30 and 60 DAT (N-S: 40.66 and 50.90 cm; E-W: 39.63 and 50.58 cm), reflecting more lateral expansion due to reduced competition, consistent with Bhargav *et al.* (2016) and Nigam *et al.* (2024) in China aster.

Increasing fertilizer levels enhanced lateral growth, with F₃ producing maximum spread (N-S: 40.28 and 50.11 cm; E-W: 38.82 and 49.48 cm at 30 and 60 DAT), highlighting the role of nutrients in promoting canopy expansion (Maheta *et al.*, 2016 and Pooja *et al.*, 2016 in China aster).

The combination of widest spacing with highest fertilizer (S₃F₃) recorded the maximum plant spread (N-S: 45.40 and 56.23 cm; E-W: 42.53 and 57.17 cm), confirming that optimum spacing and nutrition synergistically enhance canopy development (Pratheeksha *et al.*, 2024 in French marigold).

Number of primary and secondary branches

The number of primary branches increased with wider spacing (Table 3). At 30 and 60 DAT, S₃ plants produced 10.28 and 14.62 primary branches, whereas S₁ plants had 7.25 and 11.41 branches, respectively. Similarly, secondary branches were highest in S₃ (11.28 and 17.78 at 30 and 60 DAT) and lowest in S₁ (8.25 and 14.58). Wider spacing promotes lateral branching due to reduced competition, as also reported by Nigam *et al.* (2024) in China aster.

Table 2 : Influence of spacing, fertilizer and their interaction on plant spread (cm) at different stages of crop growth in China aster var. Krishna Prabha Chinmaya

Spacing (S)	Plant spread (N-S) (cm)								Plant spread (E-W) (cm)							
	30 DAT				60 DAT				30 DAT				60 DAT			
	Fertilizer (F)				Fertilizer (F)				Fertilizer (F)				Fertilizer (F)			
	F ₁	F ₂	F ₃	Mean	F ₁	F ₂	F ₃	Mean	F ₁	F ₂	F ₃	Mean	F ₁	F ₂	F ₃	Mean
S ₁ - 30 x 30 cm	30.14	34.00	36.83	33.66	35.27	42.10	45.13	40.83	27.20	33.33	36.23	32.25	37.00	40.93	44.20	40.71
S ₂ - 45 x 30 cm	35.43	36.13	38.60	36.72	43.60	44.43	48.97	45.67	34.00	34.77	37.70	35.49	41.77	42.47	47.07	43.77
S ₃ - 45 x 45 cm	36.90	39.67	45.40	40.66	46.47	50.00	56.23	50.90	36.93	39.44	42.53	39.63	45.80	48.76	57.17	50.58
Mean	34.16	36.60	40.28		41.78	45.51	50.11		32.71	35.85	38.82		41.53	44.05	49.48	
For comparing the means of	S.Em±			C.D @ 5%	S.Em±			C.D @ 5%	S.Em±			C.D @ 5%	S.Em±			C.D @ 5%
Spacing (S)	0.37			1.12	0.55			1.65	0.38			1.15	0.49			1.47
Fertilizer (F)	0.37			1.12	0.55			1.65	0.38			1.15	0.49			1.47
S X F	0.65			1.94	0.96			2.87	0.67			2.00	0.85			2.54

Fertilizer (F): F₁ - 180:120:60 NPK kg/ha, F₂ - 205:135:70 NPK kg/ha, F₃ - 225:150:75 NPK kg/ha; DAT: Days after transplanting

Table 3 : Influence of spacing, fertilizer and their interaction on number of primary and secondary branches at different stages of crop growth in China aster var. Krishna Prabha Chinmaya

Spacing (S)	No. of primary branches								No. of secondary branches							
	30 DAT				60 DAT				30 DAT				60 DAT			
	Fertilizer (F)				Fertilizer (F)				Fertilizer (F)				Fertilizer (F)			
	F ₁	F ₂	F ₃	Mean	F ₁	F ₂	F ₃	Mean	F ₁	F ₂	F ₃	Mean	F ₁	F ₂	F ₃	Mean
S ₁ - 30 x 30 cm	6.09	7.67	7.98	7.25	10.25	11.84	12.15	11.41	7.09	8.67	8.98	8.25	13.42	15.00	15.32	14.58
S ₂ - 45 x 30 cm	8.33	8.67	9.33	8.78	12.50	12.84	13.50	12.94	9.33	9.67	10.33	9.78	15.66	16.00	16.67	16.11
S ₃ - 45 x 45 cm	8.82	10.03	12.00	10.28	12.99	14.20	16.66	14.62	9.82	11.03	13.00	11.28	16.15	17.37	19.83	17.78
Mean	7.75	8.79	9.77		11.91	12.96	14.10		8.75	9.79	10.77		15.08	16.12	17.27	
For comparing the means of	S.Em±		C.D @ 5%		S.Em±		C.D @ 5%		S.Em±		C.D @ 5%		S.Em±		C.D @ 5%	
Spacing (S)	0.17		0.50		0.16		0.48		0.17		0.50		0.16		0.49	
Fertilizer (F)	0.17		0.50		0.16		0.48		0.17		0.50		0.16		0.49	
S X F	0.29		0.86		0.28		0.84		0.29		0.86		0.28		0.85	

Fertilizer (F): F₁ - 180:120:60 NPK kg/ha, F₂ - 205:135:70 NPK kg/ha, F₃ - 225:150:75 NPK kg/ha; DAT: Days after transplanting

Higher fertilizer levels enhanced branching, with F₃ producing 9.77 and 14.10 primary branches and 10.77 and 17.27 secondary branches at 30 and 60 DAT, respectively. This reflects nutrient-driven stimulation of shoot growth, consistent with Monish *et al.* (2005) and Maheta *et al.* (2016) in China aster.

The interaction of spacing and fertilizer was significant and S₃F₃ consistently had the highest primary (12.00 and 16.66) and secondary (13.00 and 19.83) branches at 30 and 60 DAT, showing combined effects of adequate space and nutrition on vegetative growth (Pratheeksha *et al.*, 2024 in French marigold and Gowtham *et al.*, 2025 in Daisy).

Flowering and Flower Quality Parameters

Days to flower initiation and 50% flowering

Flower initiation was earliest under closest spacing (S₁: 30 × 30 cm) at 30 and 60 DAT (56.78 and

66.22 days) as shown in Table 4 and latest in widest spacing (S₃: 45 × 45 cm; 62.11 and 72.78 days). Dense plantings likely accelerated reproductive transition due to stress-induced competition, similar to Bhargav *et al.* (2016) in China aster.

Low fertilizer dose (F₁) induced earlier flowering (58.11 and 67.67 days), while higher doses (F₃) delayed it (61.44 and 71.78 days), reflecting extended vegetative growth with more nutrients (Tembhare *et al.*, 2016 in China aster).

Significant interactions showed earliest flowering in S₁F₁ and latest in S₃F₃, indicating a combined effect of plant density and nutrient availability on reproductive timing (Pratheeksha *et al.*, 2024 in French marigold and Gowtham *et al.*, 2025 in Daisy).

Table 4 : Influence of spacing, fertilizer and their interaction on days to flower initiation and days to 50 per cent flowering in China aster var. Krishna Prabha Chinmaya

Spacing (S)	Days to flower initiation				Days to 50% flowering			
	Fertilizer (F)				Fertilizer (F)			
	F ₁	F ₂	F ₃	Mean	F ₁	F ₂	F ₃	Mean
S ₁ - 30 x 30 cm	53.67	57.67	59.00	56.78	62.67	67.33	68.67	66.22
S ₂ - 45 x 30 cm	60.00	60.33	61.00	60.44	69.33	70.33	71.33	70.33
S ₃ - 45 x 45 cm	60.67	61.33	64.33	62.11	71.00	72.00	75.33	72.78
Mean	58.11	59.78	61.44		67.67	69.89	71.78	
For comparing the means of	S.Em±		C.D @ 5%		S.Em±		C.D @ 5%	
Spacing (S)	0.35		1.06		0.41		1.24	
Fertilizer (F)	0.35		1.06		0.41		1.24	
S X F	0.61		1.84		0.71		2.14	

Fertilizer (F): F₁ - 180:120:60 NPK kg/ha, F₂ - 205:135:70 NPK kg/ha, F₃ - 225:150:75 NPK kg/ha

Flower diameter (cm)

Flower diameter was significantly greater (Table 5) under wider spacing (S₃) with 7.72 cm than closer

spacing (S₁) with 5.17 cm, attributed to reduced competition and better nutrient absorption. Similar results were reported by Bhargav *et al.* (2016) in China aster and Nain *et al.* (2025) in African marigold.

Higher fertilizer level F₃ produced larger flowers (7.07 cm), confirming the importance of phosphorus and potassium in bloom development, corroborated by Monish *et al.* (2005) and Tembhare *et al.* (2016) in China aster.

The treatment S₃F₃ registered the maximum flower diameter (8.30 cm), aligning with observations by Pratheeksha *et al.* (2024) in French marigold and Gowtham *et al.* (2025) in Daisy.

Number of flowers per plant

Wider spacing (S₃: 45 × 45 cm) significantly increased the number of flowers per plant (43.78) compared with closer spacing (S₁: 30 × 30 cm) with 35.44 flowers (Table 5), primarily due to improved branching, leaf area and dry matter accumulation,

which enhanced the plant's capacity to bear more flowers. This agrees with reports by Bhargav *et al.* (2016) in China aster and Nain *et al.* (2025) in African marigold.

Increasing fertilizer levels also improved flower production, with F₃ (225:150:75 NPK kg/ha) recording the highest flower number (43.44), supported by findings of Monish *et al.* (2005), Maheta *et al.* (2016) and Pooja *et al.* (2016) in China aster.

The interaction S₃F₃ produced the maximum flowers (47.33), showing the synergistic influence of space and nutrients, consistent with Pratheeksha *et al.* (2024) in French marigold and Gowtham *et al.* (2025) in Daisy.



Fig. 1 : Different Stages of flowering in China aster var. Krishna Prabha Chinmaya

Table 5 : Influence of spacing, fertilizer and their interaction on flower diameter (cm), number of flowers per plant and flower yield per plant (g) in China aster var. Krishna Prabha Chinmaya

Spacing (S)	Flower diameter (cm)				No. of flower per plant				Flower yield per plant (g)			
	Fertilizer (F)				Fertilizer (F)				Fertilizer (F)			
	F ₁	F ₂	F ₁	F ₂	F ₁	F ₂	F ₃	Mean	F ₁	F ₂	F ₃	Mean
S ₁ - 30 x 30 cm	4.53	5.17	5.80	5.17	33.00	35.33	38.00	35.44	122.23	137.80	159.73	139.92
S ₂ - 45 x 30 cm	6.10	6.73	7.10	6.64	36.33	42.00	44.67	41.00	156.37	193.13	219.07	189.52
S ₃ - 45 x 45 cm	7.37	7.50	8.30	7.72	40.33	43.67	47.33	43.78	193.60	227.27	254.17	225.01
Mean	6.00	6.47	7.07		36.56	40.33	43.33		157.40	186.07	210.99	
For comparing the means of	S.Em±		C.D @ 5%		S.Em±		C.D @ 5%		S.Em±		C.D @ 5%	
Spacing (S)	0.10		0.31		0.43		1.28		2.07		6.20	
Fertilizer (F)	0.10		0.31		0.43		1.28		2.07		6.20	
S X F	0.18		0.73		0.74		2.21		3.58		10.74	

Fertilizer (F): F₁ - 180:120:60 NPK kg/ha, F₂ - 205:135:70 NPK kg/ha, F₃ - 225:150:75 NPK kg/ha

Flower Yield per plant

Flower yield per plant was strongly influenced by spacing (Table 5) where the widest spacing, S₃ (45 × 45 cm), produced the highest yield (225.01 g). The closest spacing S₁ recorded the lowest yield (139.92 g). Wider spacing likely enhanced light interception, root

spread and nutrient uptake, which together supported greater assimilate production and higher flower biomass (Nain *et al.*, 2025 in African marigold).

Fertilizer levels also showed a clear positive response. The highest dose (F₃: 225:150:75 NPK kg/ha), resulted in the maximum yield (210.99 g),

whereas F₁ gave the lowest (157.40 g). Higher nutrient availability supported stronger vegetative growth, improved photosynthetic activity and better translocation of assimilates to developing flowers supported by findings of Monish *et al.* (2005), Maheta *et al.* (2016) and Pooja *et al.* (2016) in China aster.

The interaction between spacing and fertilizer showed the combined effect of resource availability. The S₃F₃ treatment produced the highest flower yield (254.17 g), while S₁F₁ recorded the minimum (122.23 g). This indicates that optimum space along with adequate nutrient supply improves canopy efficiency, resource capture and overall reproductive output (Pratheeksha *et al.*, 2024 in French marigold)

Conclusion

The present study established that spacing and fertilizer levels significantly influenced growth, flowering and yield of China aster [*Callistephus chinensis* (L.) Nees] var. Krishna Prabha Chinmaya. Among the spacing treatments, the widest spacing of 45 × 45 cm (S₃) proved superior for plant spread, branching, flower diameter, number of flowers per plant and flower yield per plant, indicating better utilization of space and resources. Fertilizer application at 225:150:75 NPK kg/ha (F₃) markedly enhanced vegetative growth, branching, flowering attributes and flower yield, highlighting the critical role of balanced and adequate nutrition. The interaction effect further revealed that the combined application of widest spacing and highest fertilizer level (S₃F₃) resulted in the best overall performance, confirming that optimum plant spacing along with sufficient nutrient supply is essential for maximizing productivity and flower quality in China aster under the experimental conditions.

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