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EVALUATION OF THE QUANTITATIVE AND QUALITATIVE TRAITS OF CHINA ASTER VARIETIES IN DIFFERENT PLANTING TIMES UNDER SEMI-ARID CONDITIONS OF BUNDELKHAND REGION OF INDIA

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ABSTRACT

The research aimed to standardize the planting dates for different varieties of China aster in the semi – arid condition of Bundelkhand region of Uttar Pradesh during the Rabi season of 2022-23. The experimental design utilized a complete randomized design (Factorial) with 24 treatment combinations, consisting of six varieties (Arka Aadya, Arka Poornima, Arka Archana, Arka Shashank, Phule Ganesh Purple and Phule Ganesh Violet), along with four planting dates (2nd week of November, 3rd week of November, 4th week of November, and 1st week of December). The results indicated that among the different varieties Arka Aadya recorded maximum number of primary branches (15.50) per plant, secondary branches (48.02) per plant, number of leaves at full blooming (135.92) per plant, plant spread in east- west (38.73 cm) and in north- south (34.21 cm), number of flowers (64.00)per plant, flower yield per plot (6.35 kg) and flower yield per hectare (29.06 t).Whereas Phule Ganesh Violet recorded maximum flower diameter (7.48 cm) and duration of flowering (35.25 days). Among the different planting dates 2nd week of November planted have maximum primary branches (12.87) per plant, secondary branches (39.03) per plant leaf area (27.61 cm^2), flower diameter (6.07 cm), duration of flowering (35.50 days). The results indicated that among the interaction between planting dates and different varieties of China aster, it was observed that V_1xD_1 i.e. Arka Aadya planted on 2nd week of November had maximum primary branches (16.66) per plant, secondary branches (50.33) per plant, number of leaves (149.13) per plant, number of flower (74.33) per plant and flower yield per plot (7.50 kg). Whereas, V_1xD_2 i.e. Arka Aadya planted on 3rd week of November had maximum plant spread in east – west (41.20 cm) and plant spread north – south (38.67 cm).

Keywords **:** Quantitative and qualitative traits, China aster, planting times, semi-arid conditions.

Introduction

Flowers are symbol of sentiments and an essential part of religious and social ceremonies. Flowers are an integral part of age-old tradition and culture of Indian society symbolizing love, peace, passion and beauty. A flower can say lot of words to express our emotions. China aster [*Callistephus chinensis* (L.) Nees] is a half-hardy annual and commercial flower crop belonging to the family Asteraceae. It is the most important annual flower crop of India, after marigold and chrysanthemum and cultivated all around the world. The genus *Callistephus* is derived from two Greek words Kalistos meaning 'most beautiful' and Stephus, 'a crown' respectively. It was first named by Linnaeus as *Aster chinensis* and Nees changed this name to *Callistephus chinensis*. The present-day asters have been developed from a single form of wild species, *Callistephus chinensis*. It is native to China and has spread to European countries and other tropical countries (Desai, 1967). China aster is popular as cut as

well as loose flower due to its vast range of shapes, colours (pink, purple, white, rose, violet etc.) and extended vase life. Due to the broad usage of this plant in bouquets, boutonnieres and garlands its cultivation is becoming more and more popular in urban areas.

The Bundelkhand region, which lies in the north part of India, has a favourable climate and soil conditions for the cultivation of China aster. However, the cultivation of different varieties of China aster is often associated with variations in their sowing dates, which ultimately affect the yield and quality of the flowers. The quality of China aster flowers is mainly determined by the variety and the prevailing climatic conditions during the growing period. According to Nagaraju *et al.* (2004) optimal temperature and photoperiod are crucial factors in achieving blooms of good size and high quality.

The standardization of sowing dates for different varieties of China aster is crucial for enhancing the production efficiency of the crop. It can also help in reducing the production costs and improving the overall profitability of the farmers. However, the optimum sowing dates of China aster may vary depending on various factors such as climatic conditions, soil types, and the specific variety of China aster being grown. The current research study aims to investigate the effects of different sowing dates on the qualitative and quantitative traits of China aster.

Material and Methods

An experiment was conducted at the Department of Floriculture and Landscape Architecture, college of Horticulture, Banda University of Agriculture and Technology, Banda (U.P.) during Rabi season of 2022-2023. To study the effect of sowing dates for different varieties of China Aster in the semi-arid condition of Bundelkhand region. The experiment was designed as a complete randomized design (Factorial) with a total of 24 treatment combination. The treatments consisted of six varieties (V_1- Arka Aadya, V_2- Arka Poornima, V_3- Arka Archana, V_4- Arka Shashank, V_5- Phule Ganesh Purple and V_6- Phule Ganesh Violet), along with four planting dates (D_1- 2nd week of November, D_2- 3rd week of November, D_3- 4th week of November, and D_4- 1st week of December).

Seeds were sown one month before planting in well prepared nursery beds. The seedlings, which were healthy, disease-free, and of consistent size and vigor at the 3-4 leaf stage, were carefully chosen and transplanted into the field. Seedlings were transplanted in well prepared flat beds at a spacing of 30 x 30 cm in plot size 1.20 m x 1.80 m while transplanting, the soil was pressed firmly around the seedlings and watered thoroughly. Pinching operation was done one month after transplanting. The crop was applied @ 20 tonnes of FYM, NPK 72:48:24 kg per ha. Half does of nitrogen, full does of P and K were given at the time of transplanting and remaining half dose of nitrogen was applied 30 DAT. Intercultural operation, irrigation and plant protection measures were done as and when required. Recorded pooled data was analysed as per method suggested by Cochran and Cox (1992).

Plate 1 : Panoramic view of experimental plot (Growth stage)

Plate 2 : Panoramic view of experimental plot (Flowering stage)

Results

Growth parameters

Plant Height (cm)

The data presented in the table 1 shows the mean plant height at full blooming stage (cm) of six different varieties. The significant tallest variety was V_6 (Phule Ganesh Violet) with a mean height of 76.29 cm, while V_3 (Arka Archana) was shorter with mean heights of 36.28 cm. Among the different date of showing the plants from the D_2 sowing dates had heights of 58.10 cm, which were significantly higher than the heights of plants from the other planting dates. The plants with late planting which was D_4 sowing dates had a minimum plant height (56.01 cm). Interaction between varieties and sowing dates was show significant differences on plant height. The tallest plants were observed in V_6xD_2 (77.24 cm). The shortest plant height was recorded in V_3xD_4 (35.26 cm).

Number of leaves per plant

The significant effect found in number of leaves among different planting dates and different variety. Among different varieties maximum number of leaves per plant found in (V_1) Arka Aadya had 135.92 leaves. Whereas, minimum number of leaves per plant 71.95 was recorded in (V_5) Phule Ganesh Purple. Different date of planting exhibited significant effect on number of leaves per plant. The maximum number of leaves per plant recorded with D_1 having 100.63 leaves while minimum number of leaves with planting dates of D_4 having 92.19 leaves. The number of leaves per plant in China Aster plants is significantly influenced by different varieties and planting dates. The combination V_1xD_1 exhibited the highest number of leaves per plant (149.13). In contrast, V_5xD_4 had the minimum number of leaves per plant 68.52 leaves.

Plant spread (cm)

The Table 1 and 2 revealed that both planting dates and varieties play a significant role in determining the plant spread of China Aster. The plant spread has been influenced significantly by the varieties of China aster and planting dates alone and in combination. The spread of China aster plant was more in earlier plantings than the later plantings and decreased with the corresponding delay in planting time in all varieties. The plant of variety Arka Aadya attained more spread (38.71 cm in east- west and 34.21 cm in north – south direction) which may be due to the superiority of Arka Aadya over other varieties. On the other hand, minimum plant spread (28.01 cm in east – west and 25.09 cm in north – south direction) recorded in variety Phule Ganesh Purple. The plant with more spread (30.42 cm) were produced when planting was accomplished during 2nd week of November which may be ascribed to the fact that these plants could get sufficient time for putting up more vegetative growth. So, they attain comparatively wider plant spread than the later planted crops. The interactive effect of varieties and planting dates revealed maximum plant spread (41.20 cm in east – west and 38.67 cm in north – south direction) in V_1xD_2 i.e. Arka Aadya planted on 3rd week of November which may be due to the reason that 3rd week of November planted crop got maximum time to put up sufficient vegetative growth particularly the greater number of branches which was further catalyzed by the superior variety of Arka Aadya. These results are corroborated with the earlier work of Guruprasad and Reddy (2001) [9] who reported that the

best planting date of China aster is November. On the contrary, minimum plant spread (27.84 cm in east – west and 22.58 cm in north – south direction) were observed in the interaction combination V_5xD_4 i.e. when planting of Phule Ganesh Purple was done on 1st week of December.

Number of primary branches per plant

The impact of different planting dates had significant impact on number of primary branches in various varieties. The result revealed Variety Arka Aadya exhibited the highest primary branch count (15.50) compared to the other varieties across all growth stages. The minimum number of primary branches (10.89) found in variety Phule Ganesh Purple. Among different planting dates, plants planted on D_1 (2nd week of November) recorded the highest primary branch (12.87), while those planted on D_4 (1st week of December) exhibited the lowest branch (11.44). Although treatment combination V_1xD_1 (Arka Aadya planted during 2nd week of November) displayed the highest number of primary branches with 16.66 branches. V_5xD_4 (Phule Ganesh Purple planted on 1st week of December) had the lowest primary branch recorded at 10.20. It is varietal trait and variations among the genotypes are attributed to the genetic makeup of the plant.

Number of secondary branches per plant

The impact of different planting dates had significant impact on number of secondary branches in various varieties. The result revealed Variety Arka Aadya exhibited the highest secondary branch count (48.02) compared to the other varieties across all growth stages. The minimum number of secondary branches (30.94) found in variety Phule Ganesh Purple. Among different planting dates, plants planted on D_1 (2nd week of November) recorded the highest secondary branch (39.03), while those planted on D_4 (1st week of December) exhibited the lowest branch (35.23). Although treatment combination V_1xD_1 (Arka Aadya planted during 2nd week of November) displayed the highest number of secondary branches with 50.33 branches. V_5xD_4 (Phule Ganesh Purple planted on 1st week of December) had the lowest primary branch recorded at 29.34. Sowing dates play a crucial role in number of secondary branches. Early sowing, such as on 2nd week of November, resulted in superior vegetative parameters compared to later sowing dates. This may be due to, early sowing allows the crop to take advantage of favourable environmental conditions, such as higher soil moisture and temperature, which are conducive to seed germination and early growth.

Stem girth (cm)

The significant effect found in stem girth among different planting dates. Among different varieties maximum stem girth found in (V_3) Arka Shashank had 2.65 cm. Whereas, minimum stem girth 1.93 was recorded in (V_6) Phule Ganesh Violet. Different date of planting exhibited significant effect on stem girth. The maximum stem girth (2.61 cm) was reported when planting was done during 2nd week of November which may be ascribed to the fact that plant could get sufficient time and optimum environment for vegetative growth. On the other hand, minimum stem girth with planting dates of D_4 having 2.14 cm. The stem girth in China aster plants is significantly influenced by different varieties and planting dates. The combination V_4xD_1 exhibited the highest stem girth (2.88 cm). In contrast, V_6xD_4 had the minimum stem girth 1.69 cm.

Leaf area (cm^2)

The leaf area has been influenced significantly by the varieties of China aster and planting dates alone and in combination. Among the varieties 'Phule Ganesh Purple' recorded maximum leaf area (33.35cm^2) than other varieties it might be due to the superiority of Phule Ganesh Purple over other varieties. On the other hand, minimum leaf area (18.68 cm^2) was recorded in Arka Aadya. The maximum leaf area (27.61 cm^2) was reported when planting was accomplished during 2nd week of November which may be ascribed to the fact prevailing favourable environmental conditions help in development of more number of leaves per plant. The interactive effect of varieties and planting dates revealed maximum leaf area (34.61cm^2) in V_5xD_1 i.e. planting of Phule Ganesh Purple during 2nd week of November which may be due to the reason that 2nd week of November planted crop got optimum time for vegetative growth which was further enhanced by the inherent character of Phule Ganesh Purple. These results are corroborated with the earlier work of Khan *et al.* (2006) in Tulip. On the contrary, minimum leaf area (17.09 cm^2) was observed in the interaction combination V_1xD_4 i.e. when planting of Arka Aadya was done during 1st week of December.

Table 1: Effect of different variety and planting dates on growth of China aster

Variety		Plant Height (cm)	Number of leaves per plant	Plant spread (cm)		Number of Primary branches	Number of Secondary Branches	Stem girth (cm)	Leaf area (sq.cm)
				E/W	N/S				
V_1	Arka Aadya	52.13	135.92	38.73	34.21	15.50	48.02	2.56	18.68
V_2	Arka Poornima	51.78	101.98	31.16	28.21	12.62	39.52	2.20	23.85
V_3	Arka Archana	36.28	93.58	34.30	30.97	11.24	36.43	2.47	28.89
V_4	Arka Shashank	56.50	97.65	30.36	28.23	12.46	34.71	2.65	21.28
V_5	Phule Ganesh Purple	70.57	71.95	28.30	25.09	10.89	30.94	2.62	33.35
V_6	Phule Ganesh Violet	76.29	81.17	30.21	27.46	11.25	32.25	1.93	31.38
S Em±		0.23	1.15	0.55	0.72	0.22	0.43	0.09	0.38
CD at 5%		0.23	3.23	1.55	2.03	0.62	1.20	0.25	1.06
Planting Dates									
D_1	2nd week November	57.91	100.63	33.87	30.42	12.87	39.03	2.61	27.61
D_2	3rd week of November	58.10	99.93	33.51	31.32	12.81	37.01	2.52	26.67
D_3	4th week of November	57.00	95.42	31.56	27.61	12.20	36.64	2.35	25.71
D_4	1st week of December	56.01	92.19	26.76	26.76	11.44	35.23	2.14	24.96
S Em±		0.19	0.94	0.45	0.59	0.18	0.35	0.07	0.31
CD at 5%		0.19	4.28	2.05	2.69	0.82	1.59	0.03	1.40

Table 2: Interaction effect of different Variety and planting dates on growth characters of China aster

Treatment combination	Plant Height (cm)	Number of leaves per plant	Plant spread (cm)		Number of Primary branches	Number of Secondary Branches	Stem girth (cm)	Leaf area (sq.cm)
			E/W	N/S				
$T_1 = V_1 \times D_1$	53.92	149.13	40.74	33.79	16.66	50.33	2.72	20.36
$T_2 = V_1 \times D_2$	52.07	139.44	41.20	38.67	15.66	48.16	2.78	19.19
$T_3 = V_1 \times D_3$	51.87	130.33	37.95	33.11	15.38	47.27	2.44	18.08
$T_4 = V_1 \times D_4$	50.66	124.79	35.04	31.28	14.31	46.34	2.31	17.09
$T_5 = V_2 \times D_1$	52.27	105.81	32.43	28.40	13.71	41.37	2.32	25.92
$T_6 = V_2 \times D_2$	53.34	103.26	31.01	29.30	12.89	38.09	2.39	23.50
$T_7 = V_2 \times D_3$	51.13	100.49	31.14	26.93	12.52	40.18	2.14	22.87
$T_8 = V_2 \times D_4$	50.37	98.36	30.06	28.23	11.38	38.45	1.92	23.12
$T_9 = V_3 \times D_1$	37.54	95.29	36.76	34.30	11.11	38.48	2.67	30.19
$T_{10} = V_3 \times D_2$	36.40	98.12	38.03	33.26	12.18	36.82	2.58	29.41
$T_{11} = V_3 \times D_3$	35.90	92.12	32.63	27.45	10.91	35.66	2.47	28.83
$T_{12} = V_3 \times D_4$	35.26	88.80	29.78	28.96	10.75	34.75	2.17	27.11
$T_{13} = V_4 \times D_1$	56.18	97.38	30.77	29.55	12.94	36.93	2.88	22.55
$T_{14} = V_4 \times D_2$	58.14	101.99	30.74	30.56	13.48	35.47	2.79	21.15
$T_{15} = V_4 \times D_3$	56.36	96.87	30.16	26.20	12.21	34.54	2.66	20.32
$T_{16} = V_4 \times D_4$	55.32	94.37	29.76	26.62	11.22	31.90	2.26	21.10
$T_{17} = V_5 \times D_1$	71.23	71.82	30.16	25.25	11.13	32.50	2.86	34.61
$T_{18} = V_5 \times D_2$	71.42	75.20	29.29	26.02	11.53	31.05	2.52	33.91
$T_{19} = V_5 \times D_3$	70.37	72.26	27.84	26.49	10.71	30.89	2.61	32.23
$T_{20} = V_5 \times D_4$	69.27	68.52	25.91	22.58	10.20	29.34	2.48	32.63
$T_{21} = V_6 \times D_1$	76.34	84.35	32.34	31.35	11.69	34.56	2.21	32.06
$T_{22} = V_6 \times D_2$	77.24	81.61	30.80	30.10	11.12	32.48	2.08	32.83
$T_{23} = V_6 \times D_3$	76.38	80.42	29.65	25.49	11.43	31.33	1.76	31.94
$T_{24} = V_6 \times D_4$	75.19	78.29	28.04	22.91	10.76	30.63	1.69	28.69
S Em±	0.46	2.30	1.10	1.44	0.44	0.85	0.17	0.75
CD at 5%	0.53	2.64	1.26	1.65	0.50	0.98	0.20	0.86

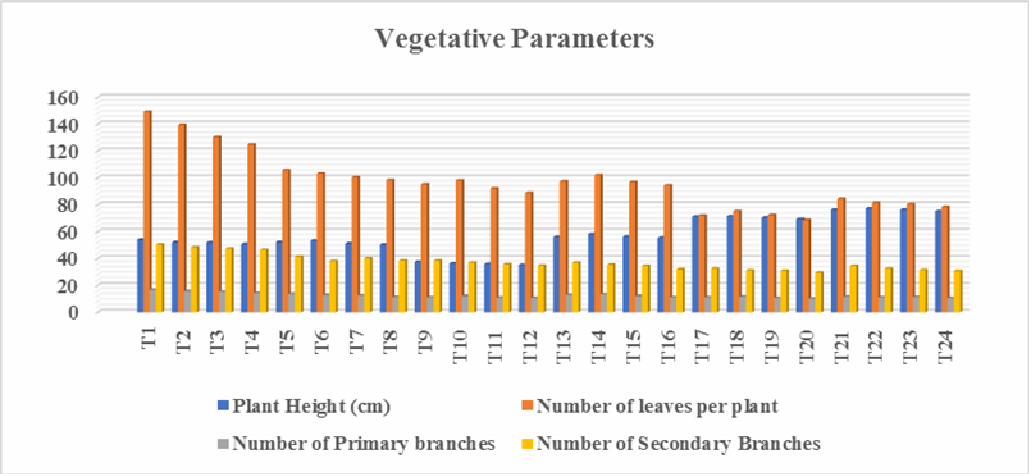

Fig. 1: Interaction effect of different Variety and planting dates on growth characters of China aster

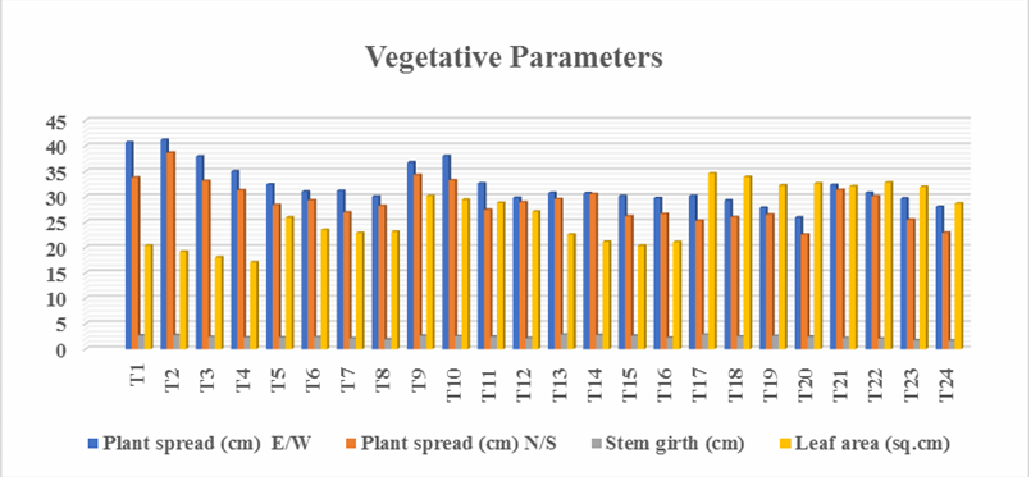

Fig. 2: Interaction effect of different Variety and planting dates on growth characters of China Aster

Flowering and yield parameters

Days to First flowering

The study examined the impact of different planting dates and varieties on the time taken for flower formation in China Aster. Significant variations were observed among varieties, with 'Arka Poornima' taking the shortest duration (94.96 days) which was statistically at par (100.95 days) in 'Arka Aadya' and 'Phule Ganesh Violet' taking the longest (112.13 days) for first flower opening. Among the planting dates, there is no significant differences were observed among the dates of planting. The minimum days to first flower opening (101.85 days) was recorded in D_3 (4^{th} week of November) the maximum duration (102.88 days) was recorded in D_4 (1^{st} week of December). The interaction between planting dates and varieties was significant, with early flowering (93.77 days) observed in the combination involving V_2xD_3 (Arka Poornima planted on 4^{th} week of November). The maximum duration (115.66 days) for first flowering was recorded in V_6xD_2 (Phule Ganesh Violet was planted on 3^{rd} week of November).

Days to 50 per cent flowering

The impact of different planting dates had significant impact on days to 50 per cent flowering in various varieties. Minimum days to 50 per cent flowering (113.75 days) were recorded in 'Arka Poornima' followed by 'Arka Shashank' (116.58 days). Whereas, maximum days to 50 per cent flowering (132.25) were observed in 'Phule Ganesh Violet'. There was no significant difference were observed on days to 50 per cent flowering by the planting dates. Among the planting dates D_3 (4th week of November) plantings recorded minimum number of days (120.20 days) for 50 per cent flowering. On the other hand, the maximum days (123.22 days) to 50 per cent flowering were recorded in D_4 (1st week of December) plantings.

The interaction between planting dates and varieties was significant, with early days to 50 per cent flowering (109.77 days) observed in the combination

involving V_2xD_2 (Arka Poornima planted on 3rd week of November). The maximum duration (135.25 days) for days to 50 per cent flowering was recorded in V_6xD_4 (Phule Ganesh Violet was planted on 1st week of December). The flower of Arka Poornima took minimum day for 50 per cent flowering over the other varieties which may be due to the genetic behaviour of Arka Poornima over other varieties. The interactive effect of varieties and planting dates revealed minimum days to 50 per cent flowering in V_2xD_2 (Arka Poornima planting on 3rd week of November) which may be due to presence of minimum temperature coupled with the shorter photoperiod.

Number of flowers per plant

The Significant variations were observed among the different varieties in terms of the number of flowers per plant. 'Arka Aadya' displayed the highest number of flowers per plant (64.00). Conversely, 'Arka Shashank' exhibited the lowest number of flowers per plant (28.50). The impact of different planting dates, it is observed that the number of flowers per plant varied across the planting dates. The highest number of flowers per plant (48.33) was recorded for planting on D2 (3rd week of November), followed by D1 (47.06). On the other hand, the lowest number of flowers per plant (37.94) was observed for plants sown on D4 (1st week of December). The treatment combination V_1xD_1 (Arka Aadya planted on 2nd week of November) resulted in the highest number of flowers per plant (74.33), while V5xD4 (Phule Ganesh Purple planted on 1st week of December) exhibited the lowest number of flowers per plant (23.33).

Flower diameter (cm)

The analysis of flower diameter revealed significant variations among different varieties. Among the varieties, 'Phule Ganesh Violet' exhibited the largest flower diameter, measuring 7.48 cm. It was followed by 'Phule Ganesh Purple' with a flower diameter of 6.77 cm. whereas, 'Arka Shashank displayed smaller flower diameters, measuring 4.58 cm respectively. Regarding the effect of planting dates, there were also significant differences observed. The largest flower diameter (6.07 cm) was recorded in plants planted on D_1 (2nd week of November), while the smallest flower diameter (5.25 cm) was observed in plants planted on D_4 (1st week of December). Among the different treatment, the largest flower size (7.87 cm) was observed in V_6xD_2, which represents 'Phule Ganesh Violet' variety planted on D_2 (3rd week of November). On the other hand, the smallest flower diameter (4.27 cm) was recorded in V_4xD_4, representing 'Arka Shashank' variety planted on D_4 (1st week of December).

Duration of flowering (days)

The impact of different planting dates had significant impact on duration of flowering in various varieties. The maximum duration of flowering (37.25 days) was recorded in 'Phule Ganesh Violet' followed by 'Phule Ganesh Purple' (37.17 days). Whereas, minimum days to duration of flowering (29.17 days) were observed in 'Arka Poornima'. There was significant difference were observed on duration of flowering by the planting dates. Among the planting dates D_1 (2nd week of November) plantings recorded maximum number of days (35.50 days) for duration of flowering which may be ascribed to the fact that plant could get sufficient time putting up more vegetative and reproductive growth. So, they have maximum duration of flowering than the later planted crops. On the other hand, the minimum days (31.48 days) to duration of flowering were recorded in D_4 (1st week of December) plantings.

The interaction between planting dates and varieties was significant, with maximum duration of flowering days (39.00 days) observed in the combination involving V_1xD_2 (Arka Aadya planted on 3rd week of November). Similar result (39.00 days) was found in V_6xD_2 (Phule Ganesh Violet) which may be due to the reason that 3rd week of November planted crop got maximum time to put up sufficient vegetative and reproductive growth which was further catalyzed by the superior genotype of Phule Ganesh Purple. The minimum duration of flowering days (27.00 days) was recorded in V_2xD_4 (Arka Poornima was planted on 1_{st} week of December) which may be ascribed to the reason that 1st week of December planted crop failed to attain sufficient vegetative growth particularly in Arka Poornima.

Flower yield per plot (kg)

The impact of different planting dates had significant impact on flower yield per plot in various varieties. The result revealed Variety Arka Aadya exhibited the maximum flower yield per plant (6.35 kg) compared to the other varieties. The minimum flower yield per plot (3.03 kg) found in variety Arka Shashank. Among different planting dates, plants planted on D_2 (3rd week of November) recorded the highest flower yield per plot (5.77 kg), while those planted on D_4 (1st week of December) exhibited the lowest flower yield per plot (4.04 kg). Although treatment combination V_1xD_1 (Arka Aadya planted during 2nd week of November) recorded maximum flower yield per plot with (7.50 kg) flowers. On the

contrary, minimum flower yield per plot (2.47 kg) was recorded in the V_4xD_4 (Arka Shashank planted during 1st week of December).

Flower yield per hectare (t)

The significant effect found in flower yield per hectare among different planting dates and different variety. The flower yield of China aster was more in earlier plantings and decreased with the corresponding delay in planting time in all varieties. Among different varieties maximum flower yield per hectare found in V_1 Arka Aadya had (29.06 t). Whereas, minimum flower yield per hectare (13.91 t) was recorded in V_4 Arka Shashank. Different date of planting exhibited significant effect on flower yield per hectare. The maximum flower yield per hectare recorded with D_2 having (26.45 t) which may be ascribed to the fact that plant could get sufficient time and optimum temperature and light for putting up more flowering. While minimum flower yield per hectare (18.44 t) planted on D_4 (1st week of December). The flower yield per hectare in China Aster plants is significantly influenced by different varieties and planting dates. The combination V_1xD_1 exhibited the highest flower yield per hectare (34.43 t). In contrast, V_4xD_4 had the minimum flower yield per hectare (11.31 t).

Table 3: Effect of different variety and planting dates on flowering characters of China Aster

Variety		Days to first flowering	Days to 50 per cent flowering	Number of flowers per plant	Flower diameter (cm)	Duration of flowering (days)	Flower yield per plot (kg)	Flower yield per hectare (t)
V_1	Arka Aadya	100.40	118.83	64.00	5.36	35.75	6.35	29.06
V_2	Arka Poornima	94.96	113.75	51.92	5.38	29.17	5.41	25.01
V_3	Arka Archana	102.42	119.08	58.25	4.77	33.58	4.97	22.79
V_4	Arka Shashank	100.45	116.58	28.50	4.58	30.75	3.03	13.91
V_5	Phule Ganesh Purple	104.78	128.42	29.42	6.77	37.17	4.45	20.39
V_6	Phule Ganesh Violet	112.13	132.25	32.67	7.48	37.25	5.93	27.11
S Em±		0.83	1.69	1.31	0.11	0.37	0.18	0.79
CD at 5%		2.33	4.74	3.69	0.32	1.04	0.50	2.22
Planting Dates								
D_1	2nd week November	102.60	121.67	47.06	6.07	35.50	5.54	25.38
D_2	3rd week of November	102.88	121.06	48.83	6.00	35.33	5.77	26.45
D_3	4th week of November	101.85	120.00	42.67	5.57	33.17	4.75	21.92
D_4	1st week of December	102.75	123.22	37.94	5.25	31.78	4.04	18.44
S Em±		0.68	1.38	1.07	0.09	0.30	0.14	0.64
CD at 5%		3.08	6.28	4.89	0.42	1.38	0.66	2.94

Table 4: Interaction effect of different variety and planting dates on flowering characters of China Aster

Treatment combination	Days to first flowering	Days to 50 per cent flowering	Number of flowers per plant	Flower diameter (cm)	Duration of flowering (days)	Flower yield per plot (kg)	Flower yield per hectare (t)
$T_1 = V_1 \times D_1$	103.04	122.33	74.33	5.96	37.67	7.50	34.43
$T_2 = V_1 \times D_2$	100.41	118.33	66.67	5.61	39.00	6.95	31.87
$T_3 = V_1 \times D_3$	97.58	116.00	59.33	5.32	34.00	5.76	26.43
$T_4 = V_1 \times D_4$	100.57	118.67	55.67	4.56	32.33	5.18	23.51
$T_5 = V_2 \times D_1$	95.20	113.33	50.67	5.68	31.33	5.59	25.64
$T_6 = V_2 \times D_2$	94.74	109.67	56.33	5.97	30.00	6.04	27.71
$T_7 = V_2 \times D_3$	93.77	114.67	54.33	5.04	28.33	5.65	26.59
$T_8 = V_2 \times D_4$	96.13	117.33	46.33	4.84	27.00	4.38	20.10
$T_9 = V_3 \times D_1$	103.13	118.33	62.67	4.81	35.33	5.63	25.84
$T_{10} = V_3 \times D_2$	100.36	119.67	65.33	5.17	34.33	5.71	26.18
$T_{11} = V_3 \times D_3$	102.18	116.00	56.67	4.62	33.33	4.74	21.72
$T_{12} = V_3 \times D_4$	104.00	122.33	48.33	4.47	31.33	3.80	17.42
$T_{13} = V_4 \times D_1$	100.33	116.33	28.67	4.91	32.00	3.21	14.69
$T_{14} = V_4 \times D_2$	99.20	117.00	34.33	4.68	31.33	3.67	16.82
$T_{15} = V_4 \times D_3$	102.50	118.00	26.67	4.45	30.00	2.79	11.31
$T_{16} = V_4 \times D_4$	99.76	115.00	24.33	4.27	29.67	2.47	24.49
$T_{17} = V_5 \times D_1$	103.17	126.00	32.33	7.46	38.00	5.35	24.16
$T_{18} = V_5 \times D_2$	106.89	129.33	34.67	6.68	38.33	5.27	17.54

$T_{19} = V_5 \times D_3$	105.10	127.67	27.33	6.63	37.33	3.82	15.54
$T_{20} = V_5 \times D_4$	103.96	130.67	23.33	6.31	35.00	3.35	15.35
$T_{21} = V_6 \times D_1$	110.76	133.67	33.67	7.61	38.67	5.93	27.17
$T_{22} = V_6 \times D_2$	115.66	132.33	35.69	7.87	39.00	6.97	31.94
$T_{23} = V_6 \times D_3$	109.99	127.67	31.65	7.38	36.00	5.76	26.40
$T_{24} = V_6 \times D_4$	112.10	135.33	29.67	7.05	35.33	5.08	22.93
S Em±	1.66	3.37	2.62	0.22	0.74	0.35	1.57
CD at 5%	1.90	3.87	3.01	0.26	0.85	0.41	1.81

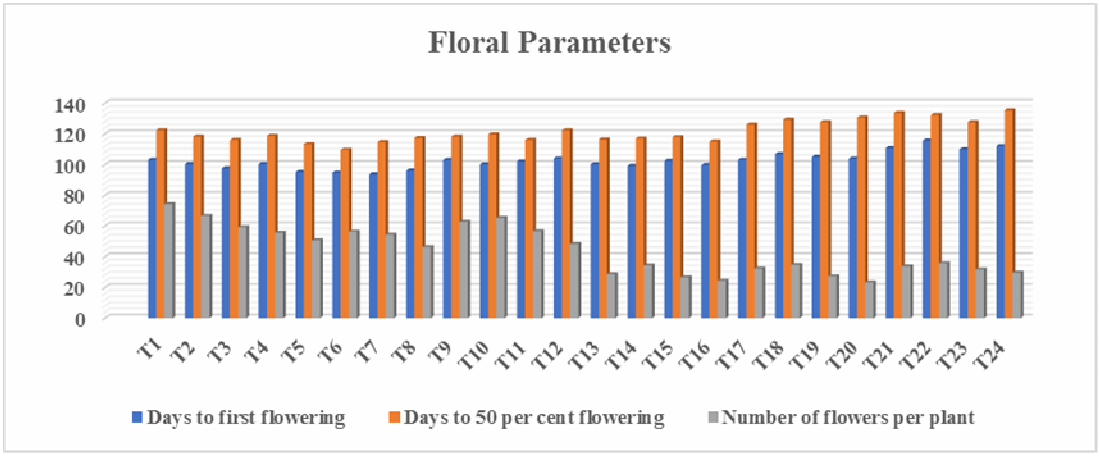

Fig. 3: Interaction effect of different variety and planting dates on flowering characters of China Aster

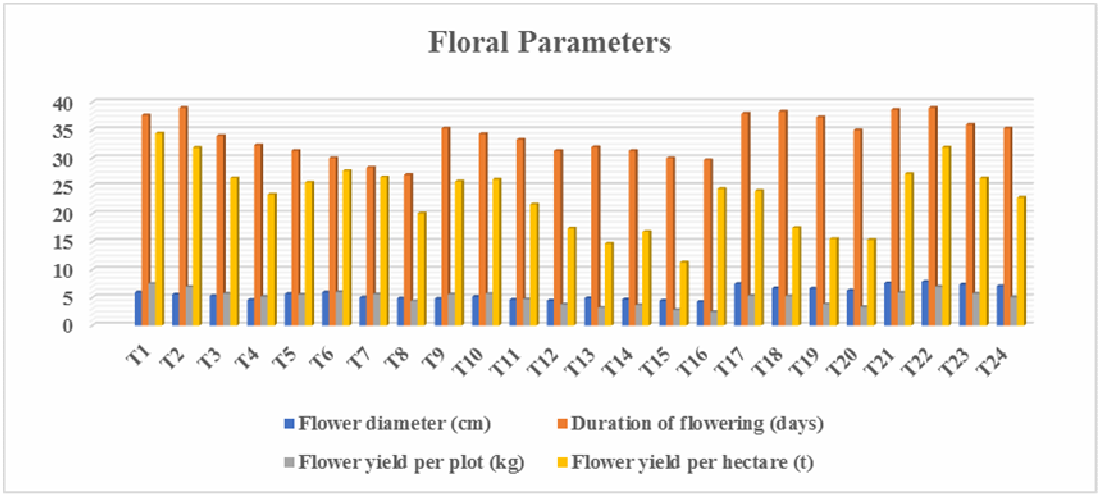

Fig. 4: Interaction effect of different variety and planting dates on flowering characters of China Aster

Table 5: Weekly meteorological data recorded for experimental period during October, 2022 to May, 2023 at BUAT, Banda

Week No.	Date	Date	Maximum Temperature (^{o}C)	Minimum Temperature (^{o}C)	Relative Humidity (%)	Average Wind Velocity (Km/ hr.)	Total Rainfall (mm)
40	02–Oct-22	08–Oct-22	33.75	25.25	84.68	2.96	7.00
41	9–Oct-22	15–Oct-22	32.86	23.71	84.38	2.24	8.14
42	16–Oct-22	22–Oct-22	34.14	21.57	66.83	2.35	0.00
43	23 –Oct-22	29–Oct-22	33.71	19.43	62.54	2.23	0.00
44	30–Oct-22	05–Nov-22	33.57	19.14	62.00	2.00	0.00
45	06–Nov-22	12–Nov-22	32.65	19.29	66.92	1.80	0.00
46	13–Nov-22	19–Nov-22	29.29	15.86	55.20	3.20	0.00
47	20–Nov-22	26– Nov-22	28.00	13.43	59.23	3.40	0.00

48	27–Nov-22	03–Dec-22	27.43	13.14	67.50	1.70	0.00
49	04–Dec-22	10–Dec-22	25.71	12.00	70.70	2.80	0.00
50	11–Dec-22	17–Dec-22	26.71	12.86	64.64	3.40	0.00
51	18–Dec-22	24–Dec-22	24.43	11.29	72.72	2.40	0.25
52	25–Dec-22	31–Dec-22	22.29	9.57	74.18	2.91	0.00
1	01–Jan-23	07–Jan-23	12.91	8.03	84.00	4.34	0.00
2	08–Jan-23	14–Jan-23	16.05	9.85	86.40	3.62	0.00
3	15–Jan-23	21–Jan-23	17.75	9.63	76.16	3.43	0.00
4	22–Jan-23	28–Jan-23	20.07	10.82	80.28	3.87	4.22
5	29–Jan-23	04–Feb-23	18.88	10.34	54.50	3.81	0.00
6	05–Feb-23	11–Feb-23	21.25	8.70	75.20	6.33	0.00
7	12–Feb-23	18–Feb-23	24.75	12.75	69.00	6.21	0.00
8	19–Feb-23	25–Feb-23	22.00	11.15	74.20	5.00	0.00
9	26–Feb-23	04–Mar-23	27.20	15.75	75.91	5.85	0.00
10	05–Mar-23	11–Mar-23	28.75	16.00	71.40	7.00	0.00
11	12–Mar-23	18–Mar-23	31.12	20.37	73.70	5.80	0.00
12	19–Mar-23	25–Mar-23	31.43	21.12	74.80	8.60	14.00
13	26–Mar-23	01–Apr-23	31.25	20.00	63.70	5.00	7.00
14	02–Apr-23	08–Apr-23	39.96	24.79	41.56	4.60	0.00
15	09–Apr-23	15–Apr-23	37.40	23.85	45.40	3.00	0.00
16	16–Apr-23	22–Apr-23	39.25	24.67	52.17	5.75	0.00
17	23–Apr-23	29–Apr-23	41.21	25.00	49.76	5.35	0.00
18	30–Apr-23	06–May-23	42.86	24.24	37.98	6.60	4.50
19	07–May-23	13–May-23	41.21	25.98	41.81	5.52	0.00
20	14–May-23	20–May-23	44.82	24.34	31.07	4.39	0.00
21	21–May-23	27–May-23	44.76	25.43	39.86	4.88	0.00

Discussion

The variation in plant height among varieties is primarily attributed to the genetic makeup of the plants. The interplay between different genes and their interactions with the environment determines the observed phenotypic variation. Similar variation in plant height due to genotypes was also observed in China aster by Atal *et al.* (2019) in China Aster, Poornima *et al.* (2006) and Zosiamliana *et al.* (2012). The plants that were planted on 3rd week of November exhibited the tallest growth, likely due to the extended duration available for vegetative growth. Consequently, these plants had a longer growth period compared to the plant planted at a later date, resulting in greater overall height. These results are in close agreement with the earlier findings of Sahu *et al.* (2023) [30] in China aster under Raipur region of Chhattisgarh conditions. Our findings are also in conformity with reports of Mohanty *et al*. (2023) in Chrysanthemum. Similar results have also been reported by Singh *et al.* (2006) in Marigold. The combination of planting dates and varieties had an interactive effect on plant height, and the study showed that the maximum plant height was observed in V_6xD_2, which refers to the planting of 'Phule Ganesh Violet' on 3rd week of November. This outcome can be attributed to the fact that the plant planted early had more time to undergo substantial vegetative growth, which was further enhanced by the superior genotype of 'Phule Ganesh Violet'. These findings align closely with the earlier research conducted by Gowda (1990) and Patil *et al*. (1987). The number of leaves per plant has been influenced significantly by the varieties of China aster and planting dates alone and in combination. The number of leaves per plant were more in var. Arka Aadya which might be due to an increase in number of primary and secondary branches per plant. Similar results are in conformity with the findings of Chowdhuri *et al.* (2016) in China aster. The maximum number of leaves was produced when planting was done during 2nd week of November which may be ascribed to the fact that plant could get sufficient time and congenial environment for synthesis of photosynthates. The results are in conformity with the earlier findings of Patil *et al.* (1987) [24] who reported that November planting exhibited the maximum number of leaves per plant. Similar results were realized by Guruprasad and Reddy (2001) in China aster.

The plant spread has been influenced significantly by the varieties of China aster and planting dates alone and in combination. The spread of China aster plant was more in earlier plantings than the later plantings and decreased with the corresponding delay in planting time in all varieties. The plant of variety Arka Aadya attained more spread which may be due to the

superiority of Arka Aadya over other varieties. The plant with more spread were produced when planting was accomplished during 2nd week of November which may be ascribed to the fact that these plants could get sufficient time for putting up more vegetative growth. So, they attain comparatively wider plant spread than the later planted crops. The results are in close agreement with the findings of Sahu *et al.* (2023) in China aster. Similar results were realized by Patil *et al.* (1987) in China aster. in V_1xD_2 i.e. Arka Aadya planted on 3rd week of November which may be due to the reason that 3rd week of November planted crop got maximum time to put up sufficient vegetative growth particularly the greater number of branches which was further catalyzed by the superior variety of Arka Aadya. These results are corroborated with the earlier work of Guruprasad and Reddy (2001) who reported that the best planting date of China aster is November.

The impact of different planting dates had significant impact on number of primary and secondary branches in various varieties. The result revealed Variety Arka Aadya exhibited the highest primary and secondary branch compared to the other varieties across all growth stages. Among different planting dates, plants planted on 2nd week of November recorded the highest primary and secondary branch. Early sowing, such as on 2nd week of November, resulted in superior vegetative parameters compared to later sowing dates. This may be due to, early sowing allows the crop to take advantage of favourable environmental conditions, such as higher soil moisture and temperature, which are conducive to seed germination and early growth. The results are in conformity with the findings of Sachin *et al.* (2023) in Chrysanthemum. Similar results were reported by Sahu *et al.* (2023), Patil *et al.* (1987) and Guruprasad and Reddy (2001) in China aster. The stem girth has not been influenced significantly by the varieties of China aster and planting dates alone and in combination. The stem of Arka Shashank attained maximum stem girth than other varieties. The maximum stem girth was reported when planting was done during 2nd week of November which may be ascribed to the fact that plant could get sufficient time and optimum environment for vegetative growth which was further catalyzed by the inherent character of Arka Shashank. Similar results were reported by Similarly, Kulkarni and Reddy (2009) also obtained the same results in case of chrysanthemum and Mahesh *et al.* (2014) found in marigold. The results are in close confirmation with the earlier findings of Kusuma (2021) in Marigold. The leaf area has been influenced significantly by the varieties of China aster and planting dates alone and in combination. Among the varieties 'Phule Ganesh Purple' recorded maximum leaf area than other varieties it might be due to the superiority of Phule Ganesh Purple over other varieties. The maximum leaf area was reported when planting was accomplished during 2nd week of November which may be ascribed to the fact prevailing favourable environmental conditions help in development of more number of leaves per plant. Similar results were also confounded by Khan *et al.* (2006) in tulip. Similar variations for leaf area were also observed previously in China aster varieties by Bhagve *et al.* (2020).

The time taken for first flower formation in China Aster is influenced by both planting dates and varieties, either individually or in combination. Significant variations were observed among varieties, with 'Arka Poornima' taking the shortest duration (94.96 days). Among the planting dates, there is no significant differences were observed among the dates of planting. The minimum days to first flower opening (101.85 days) was recorded in D_3 (4th week of November). The variation in flowering duration among different genotypes is attributed to their genetic makeup. Similar findings have been reported by Dharmendra *et al.* (2019). This result was affirmed by Rai *et al.* (2016). Delayed planting dates, such as D_4 (1st week of December) resulted in longer durations for first flower formation, possibly due to lower temperatures and reduced sunlight. Factors like soil moisture, nutrient availability, and photoperiod also affect flowering time. The results are in close confirmation with the earlier findings of Sahu *et al.* (2023) and Kishore *et al.* (2023). The flower of Arka Poornima took minimum day for 50 per cent flowering over the other varieties which may be due to the genetic behaviour of Arka Poornima over other varieties. Similar variations on days to 50 per cent flowering were also observed previously in China aster varieties by Dharmendra *et al.* (2019) who reported that minimum days to first flowering was observed in Arka Poornima. This result was affirmed by Rai *et al.* (2016). The interactive effect of varieties and planting dates revealed minimum days to 50 per cent flowering in Arka Poornima planting on 3rd week of November which may be due to presence of minimum temperature coupled with the shorter photoperiod. These results are in close agreement with the earlier work of Mohanty *et al*. (2023).

The Significant variations were observed among the different varieties in terms of the number of flowers per plant. Among the varieties tested, the 'Arka Aadya' variety displayed superior performance by producing a higher number of flowers per plant. This highlights its advantage in flower shoot production compared to the

other varieties. These findings align with previous studies conducted by Rai *et al*. (2016) in China Aster. Earlier planting dates in China Aster resulted in a higher number of flowering stems per plant compared to later planted dates. This is attributed to the plants having more time for vegetative growth, allowing for the production of additional shoots that later develop into reproductive stems. The presence of more branches also contributes to an increased number of potential flower-bearing stems. Consequently, early planting promotes greater vegetative growth and enhances flower production in China Aster. The results are also in confirmation with the findings of Sahu *et al*. (2023), Thumar *et al*. (2020) and Mohanty *et al*. (2015). The analysis of flower diameter revealed significant variations among different varieties. Maximum flower size found in Phule Ganesh Violet that might be due to environmental factors and genetic factors specific to the 'Phule Ganesh Violet' variety may also play a role in determining flower diameter. Genetic makeup can influence the overall size and development of flowers, leading to variations in diameter among plants planted on different dates. Similar variations for flower diameter were also observed previously in China aster varieties by Atal *et al.* (2019). This result was affirmed by Rai *et al*. (2016) and Dharmendra *et al.* (2019).

The impact of different planting dates had significant impact on duration of flowering in various varieties and planting dates. The interaction between planting dates and varieties was significant, with maximum duration of flowering days observed in Arka Aadya planted on 3rd week of November which may be due to the reason that 3rd week of November planted crop got maximum time to put up sufficient vegetative and reproductive growth which was further catalyzed by the superior genotype of Phule Ganesh Purple. These results are in close agreement with the earlier work of Mohanty *et al.* (2015) and Kusuma (2021). The minimum duration of flowering days Arka Poornima was planted on 1st week of December which may be ascribed to the reason that 1st week of December planted crop failed to attain sufficient vegetative growth particularly in Arka Poornima. The results are in close agreement with the earlier findings of Gaidhani *et al*. (2020) and Sharma *et al*. (2015).

The impact of different planting dates had significant impact on flower yield per plot and flower yield per hectare in various varieties and planting dates. The flower yield of China aster was more in earlier plantings and decreased with the corresponding delay in planting time in all varieties. The variety Arka Aadya has higher yield in both terms i.e. yield per plot and yield per hectare. The flower yield maximum recorded with D_2 planting dates having which may be ascribed to the fact that plant could get sufficient time and optimum temperature and light for putting up more flowering. The results are in close agreement with the earlier findings of Mohanty *et al.* (2015), Guruprasad and Reddy (2001), Mohanty *et al*. (2023) and Gaidhani *et al*. (2020).

Conclusion

Based on the current research, the following conclusions have been drawn, which can offer economic benefits for the commercial cultivation of China Aster in the Bundelkhand region of Uttar Pradesh: Among the four planting dates, favourable timing for achieving desirable growth and flowering parameters in China Aster was achieved in the variety Arka Aadya followed by Phule Ganesh Violet, was observed to be D2, referring to planting on 3rd week of November.

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