Indian Journal of Agricultural Sciences **88** (3): 453–7, March 2018/Article

Exploitation of heterosis for growth, flower quality and yield traits in China aster (*Callistephus chinensis*)

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Received: 30 June 2017; Accepted: 15 December 2017

ABSTRACT

A line × tester set of 8 parents involving five females (Arka Kamini, Arka Poornima, Arka Aadya, Arka Archana, Arka Violet Cushion) and three pollen parents (Arka Shashank, Local Violet, Local Pink) were analyzed for heterosis with respect to growth, flower quality and yield traits in China aster [*Callistephus chinensis* (L.) Nees]. The experiments were conducted at Division of Floriculture and Medicinal Crops, ICAR-Indian Institute of Horticultural Research, Bengaluru during 2015-17. Results revealed that the cross L2 × T1 exhibited highest positive significant heterosis for plant height over mid parent, better parent as well as commercial check cv. Arka Kamini. For days to first flowering, cross L3 × T1 exhibited maximum negative heterosis over commercial check. The cross L2 × T1 exhibited highest positive significant heterosis for duration of flowering over mid parent, better parent as well as commercial check. For flower stalk length, the highest positive significant heterosis over mid parent, better parent as well as commercial check was observed in cross L4 × T3. The cross L3 × T2 recorded highest heterosis for flower yield over better, mid and commercial check.

Key words: Better parent, China aster, Commercial check, Heterosis, Mid parent

China aster [*Callistephus chinensis* (L.) Nees.] belongs to the family Asteraceae and is native of China. It spread to Europe and other tropical countries during 1731 (Desai 1967).

In India, breeding in China aster was first pioneered by S S Negi and S P S Raghava in year 1984-85. Work on this aspect at ICAR-IIHR, Bengaluru led to the development of quality and high yielding varieties such as Arka Aadya, Arka Archana, Arka Kamini, Arka Poornima, Arka Shashank and Arka Violet Cushion. Presently, farmers are mainly growing local or varieties developed by public sector institutions. Hybridization is one of the breeding methods used for developing new cultivars and improve the varietal wealth, by adding new types having improved flower quality, yield and yield attributing traits.

The exploitation of hybrid vigour is an appropriate alternative for making further breakthrough in China aster. The development of F_1 hybrids with improved vegetative, flowering and yield characters is of prime importance as it enhances the marketability of a crop. A higher yield with flower quality traits over high yielding check varieties and wider adaptability will be instrumental in the development of F_1 hybrids in China aster. Commercial exploitation of heterosis in China aster is profitable. It is important that the crosses are compared with released variety rather than merely comparing with their mid or better parent.

Understanding of the transfer of traits will help in the development of F_1 hybrids with different colours such as white, pink, violet, red, scarlet, etc. and different forms like single, semi-double, pompon, powderpuff, etc. Moreover, F_1 hybrids can be developed in China aster for cut flower production with long and sturdy stalk with contrasting bigger size flower-heads, extended blooming period, higher vase life and flower yield. Raghava *et al*. (1988) reported appreciable heterobeltiosis in China aster for plant height, main branches, laterals/plant, plant spread, number of flowers/plant, stalk length, flower size, flower weight, ray florets/flower head, flowering duration and cut flower life. Keeping these points in view, the present study was undertaken to exploit heterosis for growth, flowering, yield and post-harvest traits in China aster.

MATERIALS AND METHODS

The experimental material comprised 8 genotypes of China aster. Five lines namely Arka Kamini (L1), Arka Poornima (L2), Arka Aadya (L3), Arka Archana (L4), Arka Violet Cushion (L5) were crossed with three testers namely Arka Shashank (T1), Local Violet (T2), Local Pink (T3) in line × tester fashion mating design to develop F_1 hybrids

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superior in terms of cut flower and loose flower traits. All the lines taken were stabilized and are being maintained at ICAR-IIHR, Bengaluru. The field experiment was conducted during winter season of 2015-17 for development of F_1 hybrids and their evaluation. For producing F_1 hybrid seeds, hand pollination of five lines was done with three testers in 15 combinations. The lines, testers and hybrids were planted in randomized complete block design (RCBD) with two replications at a spacing of 30 cm × 30 cm. Uniform cultural practices were followed in all the hybrids, lines and testers evaluated. The biometrical observations were recorded for plant height (cm), number of leaves/plant, number of branches/plant, days to first flowering, flower stalk length (cm), flower head diameter (cm), 100 flowers weight (g), number of ray florets/flower head, number of flowers/plant, weight of flowers/plant (g), duration of flowering (days), flower yield (t/ha), vase life (days) and shelf life (days). Data collected were averaged and analysed statistically. The statistical analysis was performed using SAS v 9.3 and biometrical analysis by using DMAST- Biometric software.

Heterosis over mid-parent heterosis (MPH), better-parent heterosis (BPH) and economic heterosis for each cross were calculated as percentage deviation from the mid-parent (MP) and better-parent (BP) values and commercial check (cv. Arka Kamini), respectively (Turner 1953).

RESULTS AND DISCUSSION

Heterosis of 15 crosses over mid parent (average heterosis), better parent (heterobeltiosis) and commercial check (standard heterosis) for 14 important parameters were estimated and results are presented in Table 1 to Table 4. Plant height is an important character which determines the usefulness of the crop for different purposes. Taller plants with longer stalks are preferred for cut flowers, while shorter ones are selected for landscaping and pot culture. Almost all the crosses were found to be taller than their respective mid parents except cross L1 × T2, L1 × T3, L3 × T3 and L5 × T3. Heterosis over mid parent ranged from -13.32 (L1 × T3) to 35.56 (L2 × T1) heterosis over better parent ranged from 16.18 (L1 × T3) to 28.72 (L2 × T1). Heterosis over commercial check ranged from -11.83 (L1 × T2) to 28.46 (L2 × T1).

Out of 15 crosses for plant height, 11 crosses showed positive heterosis over mid parent; 9 crosses showed positive heterosis over better parent and 10 crosses showed positive heterosis over commercial check. The cross L2 × T1 exhibited highest positive significant heterosis for plant height over mid parent, better parent as well as commercial check. While, the cross L1 × T3 showed highest significant negative heterosis for plant height over mid parent and better parent and cross L4 × T2 showed highest negative significant heterosis over commercial check. Panwar *et al*. (2013) observed both significantly negative and positive heterosis for plant height in marigold. The hybrids showing heterosis in negative direction could be used for flower beds, pot plants and border plants (Bayat *et al*. 2012).

Number of leaves and branches/plant are important yield determining vegetative traits. For number of leaves/plant, heterosis varied from -49.05 (L5 × T1) to 22.37 (L4 × T3) over better parent, from -48.75 (L5 × T1) to 40.88 (L3 × T2) over mid parent and from -64.72 (L5 × T1) to 26.25 (L3 × T2) over commercial check. Among all the crosses, five crosses exhibited positive heterosis over mid parent. However, 2 hybrids displayed positive heterosis

Table 1 Estimates of heterosis (%) over mid parent (MP), better parent (BP) and commercial check (CC) cv. Arka Kamini for plant height, number of leaves/plant, number of branches/plant and days to first flowering

Cross combination	Plant height (cm)			No. of leaves/plant			No. of branches/plant			Days to first flowering		
	MP	BP	CC	MP	BP	CC	MP	BP	CC	MP	BP	CC
L1 × T1	11.17*	5.46*	5.46*	-36.15	-45.96	-45.96	32.36*	32.25*	32.47*	-28.62*	-29.67*	-29.67*
L1 × T2	-6.51	-11.12	-11.12	-32.42	-34.38	-30.35	46.38*	38.38*	38.38*	-30.8*	-37.40*	-22.64*
L1 × T3	-13.32	-16.18	-10.26	-31.78	-32.05	-31.50	41.21*	28.93*	28.93*	-22.33*	-23.94*	-23.94*
L2 × T1	35.56*	28.72*	28.46*	5.74	-32.38	-53.17	56.87*	30.87*	31.10*	-22.99*	-24.94*	-23.27*
L2 × T2	19.97*	14.16*	13.93*	37.88*	-18.51	-13.51	69.13*	48.15*	31.96*	-23.41*	-30.02*	-13.53*
L2 × T3	10.52*	6.77*	14.31*	9.50*	-34.77	-34.24	48.36*	34.32*	10.96*	-14.62*	-17.28*	-15.44*
L3 × T1	25.81*	19.13*	6.89*	-18.56	-20.70	-42.04	18.82*	11.26*	27.70*	-22.73*	-30.92*	-32.96*
L3 × T2	19.55*	12.97*	1.82	40.88*	18.95*	26.25*	56.34*	78.90*	59.35*	-15.52*	-31.62*	-15.50*
L3 × T3	-1.04	-13.45	-7.34	-8.82	-11.87	-20.72	41.82*	69.43*	39.97*	-9.80*	-18.91*	-22.28*
L4 × T1	26.76*	15.32*	3.48	-16.97	-26.53	-33.91	34.19*	29.22*	39.79*	-17.41*	-23.33*	-25.60*
L4 × T2	7.74*	-2.18	-11.83	-0.71	-8.27	-2.64	33.69*	21.89*	31.86*	-15.59*	-29.40*	-12.77*
L4 × T3	9.67*	-7.50	-0.97	29.33*	22.37*	23.37*	44.67*	27.57*	38.01*	-5.461*	-11.74*	-15.40*
L5 × T1	22.24*	8.65*	25.36*	-48.75	-49.05	-64.72	1.65	-11.32	-11.17	-22.92*	-28.70*	-18.60*
L5 × T2	-1.47	-12.24	1.25	-37.44	-48.56	-45.40	3.00	-5.36	-15.70	-31.25*	-33.87*	-18.29*
L5 × T3	9.81*	5.85*	22.12*	-26.76	-38.52	-38.02	29.35*	23.09*	1.68	-25.45*	-31.43*	-21.71*

* Significant (P=0.05)

Table 2 Estimates of heterosis (%) over mid parent (MP), better parent (BP) and commercial check (CC) cv. Arka Kamini for flower head diameter, flower stalk length, number of ray florets/flower head and duration of flowering

Cross combination	Flower head diameter (cm)			Flower stalk length (cm)			No. of ray florets/ flower head			Duration of flowering (days)		
	MP	BP	CC	MP	BP	CC	MP	BP	CC	MP	BP	CC
L1 × T1	-8.08	-18.44	-18.44	-8.59	-14.55	-1.72	-41.79	-60.61	-60.61	42.26*	41.96	42.57*
L1 × T2	-9.52	-12.70	-12.70	-9.42	-16.17	-1.49	-13.66	-18.71	-7.95	25.32*	20.53*	20.53*
L1 × T3	-7.25	-13.44	-13.44	-12.71	-20.22	-3.63	-9.90	-10.92	-10.92	32.28*	26.07*	26.07*
L2 × T1	-4.92	-14.03	-17.62	8.89*	-6.43	7.63*	-58.43	11.92	-60.45	88.81*	84.64*	94.00*
L2 × T2	0.043	-1.45	-5.57	1.40	-13.64	1.49	-27.33	-13.96	-2.57	42.87*	34.23*	41.03*
L2 × T3	2.88	-2.05	-6.15	3.03	-13.24	4.80	-26.21	-4.62	-6.78	22.82*	14.37*	20.16*
L3 × T1	12.95	3.62	-3.85	6.69	-8.02	5.79	-40.69	-61.50	-54.39	48.96*	43.39*	55.65*
L3 × T2	2.56	2.47	-4.75	-6.00	-19.69	-5.62	5.94*	3.61	22.73*	41.73*	31.15*	42.37*
L3 × T3	-8.91	-11.93	-18.28	7.68*	-9.03	9.88*	-29.9	-36.05	-24.24	55.33*	42.49*	54.68*
L4 × T1	1.27	9.52	-15.16	-19.85	-28.06	-17.26	-53.58	-70.36	-62.19	19.93*	10.86*	31.20*
L4 × T2	-0.045	-1.59	-8.52	3.45	-8.03	8.08*	-26.54	-30.67	-11.54	65.58*	47.39*	74.44*
L4 × T3	11.32	13.53	-1.64	16.81*	2.62	23.95*	-20.87	-30.13	-10.85	51.00*	33.30*	57.77*
L5 × T1	-3.71	-4.95	-24.43	-40.20	-46.55	-21.96	-51.95	-68.14	-65.48	40.18*	19.19*	70.88*
L5 × T2	7.70	-0.09	-7.13	-20.84	-28.56	4.29	0.63	2.89	11.49*	21.05*	-0.49	42.67*
L5 × T3	8.14	3.69	-10.16	-30.25	-36.28	-6.97	-15.11	-19.27	-12.53	32.87*	8.42*	55.45*

* Significant (P=0.05)

Table 3 Estimates of heterosis (%) over mid parent (MP), better parent (BP) and commercial check (CC) cv. Arka Kamini for number of flowers/plant, weight of flowers/plant, 100 flower weight and flower yield

Cross combination	No. of flowers/plant			Weight of flowers/plant (g)			100 flowers weight (g)			Flower yield (t/ha)		
	MP	BP	CC	MP	BP	CC	MP	BP	CC	MP	BP	CC
L1 × T1	18.53*	6.20	6.20	6.15*	-7.66	-7.66	-9.83	-12.92	-12.92	6.01	-7.77	-7.77
L1 × T2	20.97*	3.54	3.54	15.70*	-7.28	-7.28	-3.09	-10.33	-10.33	15.47	-7.47	-7.47
L1 × T3	10.69*	3.84	3.84	18.45*	16.99*	16.99*	6.34*	0.49	12.92*	18.50	16.99	16.99
L2 × T1	82.57*	68.30*	33.29*	40.75*	27.15*	16.62*	1.05*	-14.91	15.87*	40.74	27.22	16.55
L2 × T2	70.32*	65.09*	17.52*	61.03*	33.43*	22.38*	-6.08	-23.71	3.87*	61.21*	33.63	22.42
L2 × T3	26.08*	11.10*	-2.64	-1.79	1.32	-7.07	-22.49	-29.27	-3.69	-1.81	-4.75	-7.18
L3 × T1	74.92*	64.96*	47.44*	13.03*	-9.31	10.98*	-33.92	-44.29	-24.35	12.98	-9.33	10.90
L3 × T2	90.46*	71.07*	52.91*	96.99*	47.01*	79.91*	6.27*	-13.59	17.34*	97.08*	47.09*	79.91*
L3 × T3	34.74*	33.42*	19.25*	-13.12	-21.93	-4.46	-35.32	-40.90	-19.74	-13.07	-21.91	-4.48
L4 × T1	24.93*	-2.97	38.87*	-20.36	-41.70	-7.07	-34.30	-39.64	-32.84	-19.72	-41.21	-6.34
L4 × T2	41.14*	5.68*	51.23*	39.35*	-3.97	53.05*	3.01*	-9.12	1.11	39.26*	-4.03	52.90*
L4 × T3	9.76*	-11.52	26.63*	12.24*	-9.53	44.19*	1.49*	0.99*	13.47*	12.20	-9.59	44.04*
L5 × T1	18.70*	11.07*	0.95	-14.44	-32.45	-13.67	-27.06	-39.26	-14.94	-14.43	-32.44	-13.67
L5 × T2	-9.81	-19.59	-26.91	-8.46	-32.65	-13.92	3.77*	-16.60	16.79*	-8.45	-32.64	-13.93
L5 × T3	-1.03	-2.80	-11.66	11.68*	-1.54	25.83*	12.87*	1.71*	42.44*	11.72	-1.54	25.81

* Significant (P=0.05)

over better parent and over commercial check. The cross L3 × T2 displayed highest significant positive heterosis over mid parent and commercial check. While, the highest significant positive heterosis over better parent was observed in L4 × T3. Heterosis for more number of branches/plant is desirable as more branches gives opportunity for more flower yield.

For number of branches/plant, heterosis over mid parent ranged from 1.65 (L5 × T1) to 69.13 (L2 × T2); heterosis over better parent ranged from -11.32 (L5 × T1) to 78.90 (L3 × T2) and standard heterosis over commercial check cv. Arka Kamini ranged from -15.70 (L5 × T2) to 59.35 (L3 × T2). Significant positive heterosis over mid parent, over better parent and over commercial check was

Table 4 Estimates of heterosis (%) over mid parent (MP), better parent (BP) and commercial check (CC) cv. Arka Kamini for vase life and shelf-life

Cross combination	Vase life (days)			Shelf life (days)		
	MP	BP	CC	MP	BP	CC
L1 × T1	18.16	2.88	38.79	30.92	26.69	27.69
L1 × T2	25.95	16.71	16.71	29.33	21.08	21.08
L1 × T3	60.90	60.45	61.35	12.20	6.15	6.15
L2 × T1	10.92	2.72	38.58	30.35	13.58	45.38
L2 × T2	34.51	17.18	34.70	15.80	-2.64	24.62
L2 × T3	-8.38	-14.11	-1.27	6.23	-9.86	15.38
L3 × T1	1.81	-10.25	21.09	-2.06	-21.65	24.15
L3 × T2	13.11	3.42	6.49	-13.59	-33.01	6.15
L3 × T3	33.13	31.58	35.47	13.04	-11.65	40.00
L4 × T1	-41.50	-34.42	-28.77	-28.18	-37.35	-20.00
L4 × T2	17.67	5.06	14.10	17.40	-1.20	26.15
L4 × T3	-7.62	-11.04	-3.39	11.92	-4.94	21.38
L5 × T1	7.42	-0.42	34.34	31.10	20.05	37.23
L5 × T2	24.26	8.14	24.61	27.18	12.11	28.15
L5 × T3	-0.78	-7.10	7.05	12.77	0.40	14.77

observed in 13 hybrids. The cross L2 × T2 displayed highest significant positive heterosis over mid parent, while, the highest significant positive heterosis over better parent and commercial check was observed in L3 × T2. Hassan *et al.* (2012) also reported highly positive significant heterosis estimates (MPH) in petunia for number of branches/plant in all of the cross combinations except for P3 × P1 and P4 × P3. Weerasekara *et al.* (2008) reported good amount of average heterosis over mid parent and better parent for number of branches/plant in okra.

Days to first flowering are a negative character as earliness is preferred over lateness. Plant earliness is an important character, which helps farmers to fetch early market. For days to first flowering, heterosis over mid parent ranged from -31.25 (L5 × T2) to -5.46 (L4 × T3); heterosis over better parent ranged from -37.4 (L1 × T2) to -11.74 (L4 × T3). Heterosis over commercial check cv. Arka Kamini ranged from -32.96 (L3 × T1) to -12.77 (L4 × T2). All the 15 crosses showed significant negative heterosis over mid parent, better parent as well as commercial check. Among them, cross L3 × T1 exhibited maximum negative heterosis over commercial check cv. Arka Kamini. Manivannan *et al.* (2005) have also reported earliness in sunflower hybrids.

Flower head diameter and flower stalk length are decisive characters for selection of a genotype for a cut flower. Heterosis over mid parent ranged from -9.52 (L1 × T2) to 12.95 (L3 × T1), heterosis over better parent ranged from -18.44 (L1 × T1) to 13.53 (L4 × T3). Standard heterosis over commercial check cv. Arka Kamini ranged from -24.43 (L5 × T1) to -1.64 (L4 × T3). But, none of the 15 hybrids showed significant heterosis over mid parent, over better parent and over commercial check cv. Arka Kamini.

For flower stalk length, heterosis over mid parent ranged from -40.20 (L5 × T1) to 16.81 (L4 × T3); over better parent ranged from -46.55 (L5 × T1) to 2.62 (L4 × T3). Standard heterosis ranged from -21.96 (L5 × T1) to 23.95 (L4 × T3). Three hybrids recorded positive significant heterosis over mid parent. None of the hybrids recorded positive significant heterosis over better parent. Four hybrids recorded significant positive heterosis over commercial check cv. Arka Akmini. The cross L4 × T3 exhibited highest significant positive heterosis over mid parent, better parent and the highest significant positive heterosis over commercial check. Upputuri (2014) reported significant positive standard heterosis for flower stalk length by 19 out of 20 hybrids in China aster. The maximum heterosis for flower stalk length was also reported by Panwar *et al.* (2013) in marigold. Stalk length is one of the important trait for cut flower in China aster. Hence, positive heterosis for stalk length is desirable.

Number of ray florets/flower head enhances the attractiveness of a flower. For number of ray florets per flower head heterosis over mid parent ranged from -58.43 (L2 × T1) to 5.94 (L3 × T2); heterosis over better parent ranged from -70.36 (L4 × T1) to 11.92 (L2 × T1). Standard heterosis over commercial check cv. Arka Kamini ranged from -65.48 (L5 × T1) to 22.73 (L3 × T2). The cross L3 x T2 showed significant heterosis over mid parent for number of ray florets/flower head. None of the hybrids showed significant heterosis over better parent. Two hybrids (L3 × T2 and L5 × T2) showed positive significant heterosis over commercial check cv. Arka Kamini. Patil (1991) also reported that the maximum heterobeltiosis for ray florets/flower was low (4.53 %).

Duration of flowering is important trait for landscape garden and in commercial cultivation as it facilitates extended number of pickings. Planting of genotypes with variable flowering period extend flowering for longer duration. Since, the number of days taken to first flower opening is a varietal trait, it can be reduced through the use of heterosis.

For duration of flowering heterosis over mid parent ranged from 19.93 (L4 × T1) to 88.81 (L2 × T1); heterosis over better parent ranged from -0.49 (L5 × T2) to 84.64 (L2 × T1). Standard heterosis ranged from 20.16 (L2 × T3) to 94.00 (L2 × T1). All the 15 crosses exhibited significant positive heterosis over mid parent and commercial check. All the crosses, except L1 × T1 and L5 × T2, exhibited significant positive heterosis over better parent. Among them, L2 × T1 exhibited highest positive significant heterosis for duration of flowering over mid parent, better parent as well as commercial check cv. Arka Kamini.

Number of flowers/plant, weight of flowers/plant and 100 flowers weight contribute to yield. For these characters, significant heterosis was observed in number of crosses. For number of flowers/plant heterosis over mid parent ranged from -9.81 (L5 × T2) to 90.46 (L3 × T2); heterosis over better parent ranged from -19.59 (L5 × T2) to 71.07 (L3 × T2). Standard heterosis over commercial check cv. Arka Kamini ranged from -26.91 (L5 × T2) to 52.91 (L3

× T2). For number of flowers/plant, out of 15 crosses, 13 crosses recorded positive significant heterosis over mid parent; 8 hybrids recorded positive significant heterosis over better parent. Eight crosses recorded positive significant heterosis over commercial check. Among them, L3 × T2 exhibited highest positive significant heterosis for number of flowers/plant over mid parent, better parent as well as commercial check. Raghava *et al*. (1988) reported highest heterobeltiosis (126.96 %) in China aster for number of flowers/plant. Sureshkumar (2003) also reported heterosis over standard check cv. Kamini for the character number of flowers/plant in China aster.

For weight of flowers/plant, heterosis over mid parent ranged from -20.36 (L4 × T1) to 96.99 (L3 × T2) and heterosis over better parent ranged from -41.7 (L4 × T1) to 47.01 (L3 × T2). Standard heterosis over commercial check cv. Arka Kamini ranged from -13.92 (L5 × T2) to 79.91 (L3 × T2). Out of 15 crosses, 10 crosses recorded positive significant heterosis over mid parent; 4 crosses displayed positive significant heterosis over better parent and 8 crosses recorded positive significant heterosis over commercial check cv. Arka Kamini. For 100 flowers weight heterosis over mid parent ranged from -35.32 (L3 × T3) to 12.87 (L5 × T3); heterosis over better parent ranged from -44.29 (L3 × T1) to 1.71 (L5 x T3). Standard heterosis over commercial check cv. Arka Kamini ranged from -32.84 (L4 × T1) to 42.44 (L5 × T3). Among 15 crosses, 7 crosses displayed positive significant heterosis over mid parent; 2 crosses observed positive significant heterosis over better parent and 7 hybrids recorded positive significant heterosis over commercial check. Among them, L5 × T3 exhibited highest positive significant heterosis for 100 flowers weight over mid parent, better parent as well as commercial check. These findings are in agreement with the results of Raghava *et al*. (1988) who reported significant heterobeltiosis for average flower weight and is contradictory with the findings of Sureshkumar *et al*. (2004) who observed negative heterobeltiosis for this trait.

Flower yield is the most important factor of productivity for commercial cultivation of China aster flowers. Flowers with good quality character along with good yield will always be preferred by growers. For flower yield, heterosis over mid parent ranged from -19.72 (L4 × T1) to 97.08 (L3 × T2); heterosis over better parent ranged from -41.21 (L4 × T1) to 47.09 (L3 × T2). Standard heterosis over commercial check cv. Arka Kamini ranged from -13.93 (L5 × T2) to 79.91 (L3 × T2). Among 15 hybrids, 3 hybrids observed positive significant heterosis over mid parent; only one cross observed positive significant heterosis over better parent. Three crosses recorded positive significant heterosis over commercial check cv. Arka Kamini. Cross L3 × T2 exhibited highest positive significant heterosis for flower yield over mid parent, better parent as well as commercial check cv. Arka Kamini.

Vase life and shelf-life are important parameters for cut flower and loose flower, respectively. Heterosis over mid parent ranged from -41.50 (L4 × T1) to 60.90 (L1 × T3); heterosis over better parent ranged from -34.42 (L4 × T1) to 60.45 (L1 × T3). Standard heterosis over commercial check cv. Arka Kamini ranged from -28.77 (L4 × T1) to 61.35 (L1 × T3). For vase life, none of the crosses showed significant heterosis over mid parent, better parent and over commercial check cv. Arka Kamini.

For shelf-life, heterosis over mid parent ranged from -28.18 (L4 × T1) to 31.10 (L5 × T1); heterosis over better parent ranged from -37.35 (L4 × T1) to 26.69 (L1 × T1). Standard heterosis over commercial check cv. Arka Kamini ranged from -20.0 (L4 × T1) to 45.38 (L2 × T1). For shelf-life, none of the crosses showed significant heterosis over mid parent, better parent and over commercial check cv. Arka Kamini.

Hence, it can be concluded that heterosis can be exploited for growth, flower quality and yield related traits except for flower head diameter, vase life and shelf-life. Since these are the essential traits which directly or indirectly affect the production potential of the crop, therefore, focus should be given to evolve F_1 hybrids with improved flower quality and yield in China aster.

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