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Exploitation of heterosis for yield and quality traits in China aster [*Callistephus chinensis* (L.) Nees]

Mrutyunjaya SH, Mukund Shiragur, BC Patil, Vijayakumar Rathod, Lakshmidevamma TN and Preetham SP

Abstract
A line x tester analysis was carried out involving five lines (Namdhari Pink, Namdhari White, Miraj Local, Arka Poornima and P.G. Purple) and two testers (Arka Kamini and AAC-1) were analysed for heterosis for 13 economic traits in China aster. The experiment was conducted at Department of Floriculture and Landscape Architecture, Kittur Rani Channamma College of Horticulture, Arabhavi, Karnataka during 2019-20. Miraj Local x AAC-1 and P.G. Purple x Arka Kamini exhibited significant positive heterosis for majority of the traits including yield parameters. Namdhari Pink x Arka Kamini and Arka Poornima x AAC-1 reported significant negative heterosis for days to first flowering and days to 50 per cent flowering.

Keywords: better parent, China aster, heterosis, mid parent, standard check

Introduction
China aster (*Callistephus chinensis* (L.) Nees.) is a commercially grown half hardy annual flowering crop. It is diploid with chromosome number 2n=18 (Strube, 1965) [9] and belongs to the family Asteraceae. It is primarily originated from China. During 18th century it spread to other tropical and subtropical countries including Europe (Desai, 1967) [5]. China aster has been developed from a single wild species *Callistephus chinensis*. Karnataka, Tamil Nadu, Andhra Pradesh, Maharashtra (Pune and Nasik) and West Bengal are the states which cultivate this crop commercially. It is cultivated in Karnataka in an area of 666 hectares, with a production of 5661 MT and a productivity of 8.50 tons per hectare, with an annual income of 1525 lakhs (Anon., 2018) [3].
The ornamental plant market is highly dynamic and always demands constant novelties. The existing commercial cultivars in India have semi-double flowers with prominent disks and short flower stalks (Singh, 2006) [7]. Hence, development of China aster for both cut and loose flower need improvement in quality attributes such as flower color, flower stalk length, flower shape, flower size and increased vase life.
Heterosis is one among the breeding methods suggested when the gene action in the expression of traits is non-additive type. The use of heterosis has proved to be one of the most viable methods of breeding to increase productivity and production (Singh and Chaudhary, 1985) [8]. Hybrids have distinct advantages over open pollinated varieties such as earliness, profuse and uniform flowering, increased flower weight, large flower size, elongated flower stalk, longer flower duration *etc*. Keeping these points in view, the present study was undertaken to exploit heterosis for yield and quality traits in China aster.

Material and methods
The present study was conducted in the research field of Department of Floriculture and Landscape Architecture of Kittur Rani Channamma College of Horticulture, Arabhavi, Karnataka during 2019-20. The experimental material comprised of seven genotypes of China aster. Five lines namely Namdhari Pink, Namdhari White, Miraj Local, Arka Poornima and P. G. Purple were crossed with two testers namely Arka Kamini and AAC-1 in line × tester mating design to develop ten F_1 hybrids. Arka Kamini was used as standard check. For producing F_1 hybrid seeds, hand pollination of five lines was done with two testers in ten combinations. The lines, testers and hybrids were planted in randomized complete block design (RCBD) with three replications at a spacing of 30 cm × 30 cm. Uniform cultural practices were followed in all the hybrids, lines and testers evaluated.

The observations were recorded for namely plant height, stem girth, number of branches, days to first flowering, days to 50 per cent flowering, duration of flowering, flower stalk length, flower weight, flower diameter, number of flowers per plant, flower yield per plant and vase life. All statistical analysis were performed using WINDOSTAT version 8.6. Mid-parent heterosis (MPH), better parent heterosis (BPH) and heterosis over standard check for each cross were calculated as percentage deviation from the mid-parent (MP) and better-parent (BP) values and commercial check (Arka Kamini), respectively (Turner 1953) [11].

Result and Discussion

Heterosis of ten crosses over mid parent (average heterosis), better parent (heterobeltiosis) and standard check (standard heterosis) for 13 parameters were estimated and results were furnished in Table 1. to Table 4. Plant height determines growth and vigorness of the plant. Tall plants with long flower stalk length are preferred for cut flower purpose, while dwarf plants are selected for landscaping and as potted plants. Nine crosses over mid parent, nine crosses over better parent and ten crosses over standard check exhibited significant positive heterosis. P.G. Purple x Arka Kamini and Namdhari White x AAC-1 reported highest heterosis over mid, better and standard check. Heterosis over mid parent ranged from 0.91 (Namdhari Pink × AAC-1) to 43.90 per cent (P.G. Purple × Arka Kamini), over better parent ranged between -12.44 (Namdhari Pink × AAC-1) to 21.92 per cent (P.G. Purple × Arka Kamini). The range of heterosis over standard check Arka Kamini was observed from 17.73 (Namdhari White × Arka Kamini) to 82.62 per cent (Arka Poornima × AAC-1). Namdhari Pink × AAC-1 was the only parent which showed heterosis in negative direction. This is in accordance with the research findings of Pavani (2014) [6] and Anjali (2015) [2] in China aster.

For stem girth, heterosis over mid parent ranged from -4.00 (Arka Poornima × Arka Kamini) to 27.59 per cent (P.G. Purple × Arka Kamini), over better parent from -14.29 (Arka Poornima × Arka Kamini) to 10.78 (Namdhari Pink × Arka Kamini) and over standard check from 9.09 (Arka Poornima × Arka Kamini) to 51.52 per cent (P.G. Purple × Arka Kamini). P.G. Purple x Arka Kamini exhibited highest heterosis over mid, better and standard check. Similar observations were made by Suresh kumar *et al.* (2004) [5] in China aster. Number of branches is the important parameter that decides the density of plant contributing to productivity. Among ten crosses, three crosses over mid parent, two crosses over better parent and eight crosses over standard check showed significant heterosis and all were in positive direction. P.G. Purple x Arka Kamini exhibited highest heterosis over mid parent (48.03), better parent (23.72) and standard check (84.24). Similar results were confirmed by Anjali (2015) [2] and Bhargav *et al.* (2019) [4] in China aster.

Early flowering is a desirable character in most of the crops hence, negative heterosis is preferred for days to first flowering. Magnitude of heterosis over mid parent was from -18.51 (Arka Poornima × AAC-1) to 4.03 per cent (Namdhari White × Arka Kamini), over better parent from -17.42 (Arka Poornima × AAC-1) to 10.82 per cent (Namdhari White × Arka Kamini). The range of heterosis from -19.20 (Namdhari Pink × Arka Kamini) to 5.41 per cent (Miraj Local × AAC-1) was noticed over standard check Arka Kamini. Namdhari Pink x Arka Kamini reported highest negative heterosis over standard check. This results in line with the findings of Pavani (2014) [6] and Bhargav *et al.* (2019) [4] in China aster.

For days to 50 per cent flowering, range of mid parent heterosis varied from -17.93 (Miraj Local × Arka Kamini) to 4.01 per cent (Namdhari White × Arka Kamini), better parent heterosis ranged from -16.38 (Arka Poornima × AAC-1) to 9.54 per cent (Namdhari White × Arka Kamini). Heterosis over standard check ranged from -16.95 (Namdhari Pink × Arka Kamini) to 3.30 per cent (Miraj Local × AAC-1). Nine crosses over mid parent, six crosses over better parent and four crosses over standard check reported negative significant heterosis. These results were confirmed by Suresh Kumar *et al.* (2004) [5] and Anjali (2015) [2] in China aster.

Heterosis in positive direction is desirable for flower duration. Increase in flower duration helps in continuous harvest of the flowers for longer days. All the ten crosses exhibited significant heterosis over mid, better and standard check and most were in positive direction. P.G. Purple x AAC-1(29.68%) resulted maximum heterosis over standard check and showed significant heterosis over mid, better and standard check. Anita *et al.* (2003) [1] in marigold and Pavani (2014) [6] in China aster reported positive significant heterosis for duration of flowering.

For cut flower purpose, flower stalk length is an important character. Eight crosses over mid parent, five crosses over better parent and eight crosses over standard check exhibited positive significant heterosis. P.G. Purple × Arka Kamini (28.73), Namdhari White × Arka Kamini (21.58) and P.G. Purple × AAC-1 (47.37) were the top crosses that reported positive significant heterosis over mid, better and standard check, respectively. Similar results were confirmed by Gupta (2001) in marigold. Individual flower weight directly correlates with the yield component. Heterosis over mid parent ranged from -5.89 (Namdhari Pink × AAC-1) to 28.25 per cent (Namdhari White × Arka Kamini), over better parent ranged from -12.78 (Namdhari Pink × AAC-1) to 19.82 per cent (Namdhari White × Arka Kamini). Heterosis over standard check Arka Kamini ranged from 13.15 (Namdhari Pink × Arka Kamini) to 57.51 per cent (Miraj Local × AAC-1). Miraj Local x AAC-1 and Arka Poornima x AAC-1 were the top crosses that reported positive significant heterosis over mid, better and standard check. Similar observations were made by Anita *et al.* (2003) [1] in marigold and Anjali (2015) [2] in China aster.

Flower diameter is the trait that increases the utility as both cut and loose flower and also positively correlates with the yield component. Heterosis over mid parent ranged from -8.24 (Namdhari Pink × AAC-1) to 14.07 per cent (P.G. Purple × Arka Kamini), over better parent from-15.60 (Namdhari Pink × AAC-1) to 26.80 per cent (P.G. Purple × Arka Kamini) and over standard check from 0.28 per cent (Miraj Local × Arka Kamini) to 33.77 per cent (Miraj Local × AAC-1). Eight crosses over mid parent, six crosses over better parent and eight crosses over standard check exhibited significant positive heterosis. Miraj Local x AAC-1 showed positive significant heterosis over mid, better and standard check. These findings are in agreement with the results of Bhargav *et al.* (2019) [4] in China aster.

Number of flowers per plant is an important trait that directly contributes to yield. Heterosis over mid parent ranged from 1.84 to 19.91 per cent for Miraj Local × AAC-1 and P.G. Purple × Arka Kamini, respectively, over better parent ranged from -3.67 per cent (Namdhari Pink × AAC-1) to 9.21 per cent (Miraj Local × Arka Kamini). Heterosis over standard check Arka Kamini ranged from 7.07 (Arka Poornima × Arka

Kamini) to 44.57 per cent (P.G. Purple × Arka Kamini). Seven crosses over mid parent, two crosses over better parent and ten crosses over standard check exhibited significant positive heterosis. P.G. Purple x Arka Kamini reported highest heterosis over standard check. Results obtained were similar to that of Pavani (2014) [6] and Anjali (2015) [2] in China aster.

Flower yield per plant is an imperative trait to increase the productivity. Positive heterosis is desirable for the trait. Eight crosses over mid parent, six crosses over better parent and ten crosses over standard check reported significant positive heterosis. Top three hybrids with mid parent heterosis were Arka Poornima × Arka Kamini (44.07%), Namdhari White × Arka Kamini (39.37%) and Arka Poornima × AAC-1 (31.33%). Top three hybrids over better parent heterosis were Arka Poornima × Arka Kamini (38.13%), Namdhari White × Arka Kamini (24.20%) and Miraj Local × AAC-1 (20.21%). Top three hybrids showing heterosis over standard check Arka Kamini were, Miraj Local × AAC-1 (93.20%), Arka Poornima × AAC-1 (77.11%) and P.G. Purple × Arka Kamini (76.95%). Similar results were confirmed by Pavani (2014) [6] and Anjali (2015) [2] in China aster.

Flower yield per hectare is one of the significant attributes which seeks main attention in a crop improvement. Direction of heterosis desirable for this trait is positive. Eight crosses over mid parent, seven crosses over better parent and ten crosses over standard check exhibited significant positive heterosis. Miraj Local x AAC-1(93.39%) reported maximum heterosis over standard check and also showed positive significant heterosis over mid and better parent. Arka Poornima x Arka Kamini showed highest heterosis over both mid parent (42.55%) and better parent (36.68%). Observed results are in conformity with the findings of Anjali (2015) [2] and Bhargav *et al.* (2019) [4] in China aster.

Vase life is a major quality parameter as increase in vase life implies the enhancement of utility of cut flowers. Nine crosses over mid parent, five crosses over better parent and ten crosses over standard check reported significant positive heterosis. P.G. Purple x AAC-1 showed maximum heterosis over standard check (40.55%) and also positive significant heterosis over mid and better parent. Bhargav *et al.* (2019) [4] in China aster also observed significant positive heterosis for vase life.

Table 1: Estimates of heterosis (%) for plant height, stem girth and number of branches

Sl. No	Crosses	Plant height (cm)			Stem girth (cm)			Number of branches		
		MP	BP	SC	MP	BP	SC	MP	BP	SC
1	Namdhari Pink × AAC-1	0.91	-12.44 **	37.23 **	8.82 **	6.86 **	23.86 **	4.13	1.08	26.63**
2	Namdhari Pink × Arka Kamini	12.47 **	5.03 **	21.04**	18.95 **	10.78 **	28.41 **	8.98	0.69	18.75*
3	Namdhari White × AAC-1	19.54 **	2.41 *	60.52**	7.95 **	7.77 **	20.83 **	4.24	-1.30	23.64 *
4	Namdhari White × Arka Kamini	11.16 **	5.29 **	17.73 **	15.71 **	9.46 **	22.73 **	3.59	-1.94	9.78
5	Miraj Local × AAC-1	13.68 **	9.95 **	72.34 **	12.44 **	7.41 **	31.82 **	12.64*	8.24	35.60 **
6	Miraj Local × Arka Kamini	25.18 **	5.33 **	54.26**	11.56 **	1.23	24.24 **	26.10**	17.65 *	35.87 **
7	Arka Poornima × AAC-1	26.23 **	16.52 **	82.62 **	5.55 **	-0.89	26.14 **	11.53	-3.47	20.92 *
8	Arka Poornima × Arka Kamini	26.93 **	11.32 **	47.64 **	-4.00 *	-14.29 **	9.09 **	12.06	7.34	7.34
9	P.G. Purple × AAC-1	14.62 **	9.95 **	72.34 **	1.82	-7.71 **	26.89 **	6.05	-2.37	45.38 **
10	P.G. Purple × Arka Kamini	43.90 **	21.92 **	75.53 **	27.59 **	10.19 **	51.52 **	48.03 **	23.72 **	84.24 **
	S.Em ±	0.40	0.46	0.46	0.01	0.01	0.01	0.88	1.02	1.02
	C.D at 5%	0.84	0.97	0.97	0.03	0.04	0.04	1.86	2.15	2.15
	C.D at 1%	1.15	1.33	1.33	0.04	0.05	0.05	2.55	2.94	2.94

*Significant at 5 per cent level ** Significant at 1 per cent level
MP- Mid parent BP- Better parent SC- Standard check (Arka Kamini)

Table 2: Estimates of heterosis (%) for days to first flowering, days to 50 per cent flowering and duration of flowering

Sl. No	Crosses	Days to first flowering			Days to 50 per cent flowering			Duration of flowering (days)		
		MP	BP	SC	MP	BP	SC	MP	BP	SC
1	Namdhari Pink × AAC-1	-5.71**	1.92	-3.69	-5.27**	3.28	-2.82	-1.62**	-8.92**	7.63**
2	Namdhari Pink × Arka Kamini	-16.91 **	-14.44**	-19.20 **	-14.40 **	-11.64**	-16.95 **	3.75**	3.42**	4.09**
3	Namdhari White × AAC-1	-4.75 **	6.87**	-5.71 **	-3.43 *	7.69**	-2.66	-3.77**	-9.46**	6.99**
4	Namdhari White × Arka Kamini	4.03 *	10.82**	-2.12	4.01 *	9.54**	-0.94	5.42**	3.30**	7.63**
5	Miraj Local × AAC-1	-5.03 **	-4.00*	5.41 **	-8.22**	-7.06**	3.30	4.64**	1.64**	20.11**
6	Miraj Local × Arka Kamini	-17.93 **	-12.89**	-12.94 **	-17.93 **	-12.11**	-12.19**	7.93**	2.41**	14.09**
7	Arka Poornima × AAC-1	-18.51 **	-17.42**	-11.67 **	-17.64 **	-16.38**	-9.91 **	-1.56**	-10.74**	5.48**
8	Arka Poornima × Arka Kamini	-1.00	2.57	2.48	-2.81 *	0.90	0.90	6.91**	4.84**	4.84**
9	P.G. Purple × AAC-1	-13.83 **	-12.32**	-7.12 **	-9.26**	-7.15**	-1.37	6.02**	2.55**	29.68 **
10	P.G. Purple × Arka Kamini	-14.10 **	-11.53**	-11.62 **	-12.36 **	-9.53**	-9.61 **	13.11**	1.28**	28.06 **
	S.Em ±	1.04	1.20	1.20	1.06	1.23	1.23	0.06	0.07	0.07
	C.D at 5%	2.19	2.53	2.53	2.24	2.59	2.59	0.13	0.15	0.15
	C.D at 1%	3.00	3.46	3.46	3.07	3.55	3.55	0.18	0.20	0.20

*Significant at 5 per cent level ** Significant at 1 per cent level
MP- Mid parent BP- Better parent SC- Standard check (Arka Kamini)

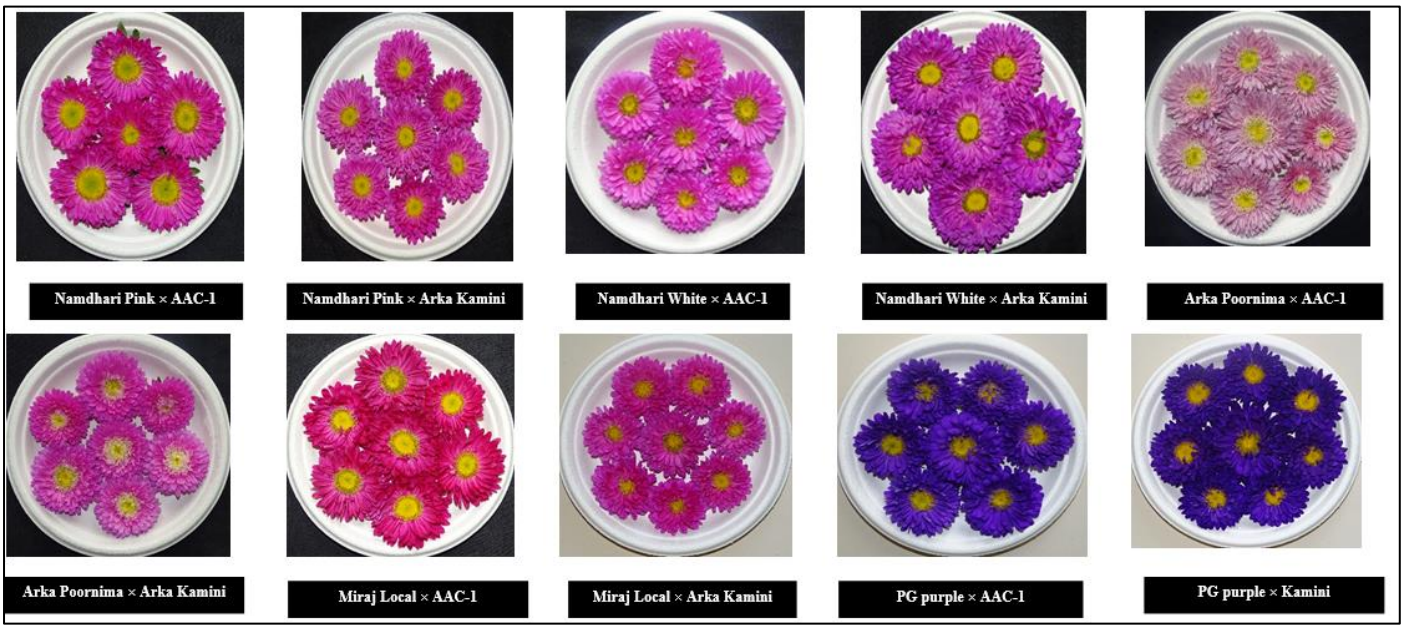

Fig 1: Flowers of crosses developed from hybridisation

Table 3: Estimates of heterosis (%) for flower stalk length, individual flower weight and flower diameter

Sl. No	Crosses	Flower stalk length (cm)			Individual flower weight (g)			Flower diameter (cm)		
		MP	BP	SC	MP	BP	SC	MP	BP	SC
1	Namdhari Pink × AAC-1	-8.24 **	-20.41 **	2.63	-5.89 **	-12.78 **	14.44 **	-6.22*	-15.60**	3.11
2	Namdhari Pink × Arka Kamini	8.29 *	5.44	5.44	6.75 **	1.04	13.15 **	9.40**	8.15**	8.15**
3	Namdhari White × AAC-1	6.44 *	-9.78 **	16.33 **	14.74 **	7.72 **	41.33 **	5.04*	-3.90	17.40**
4	Namdhari White × Arka Kamini	28.21 **	21.58 **	21.58 **	28.25 **	19.82 **	37.95 **	14.33**	15.12**	15.12**
5	Miraj Local × AAC-1	7.08 **	5.99 *	36.67 **	19.31 **	18.58 **	57.51 **	11.67**	9.50**	33.77**
6	Miraj Local × Arka Kamini	11.63 **	0.00	26.32 **	7.40 **	-5.87 **	25.03 **	-7.75**	0.28	0.28
7	Arka Poornima × AAC-1	4.73	-8.27 **	18.28 **	18.98 **	12.33 **	47.38 **	5.69*	-0.28	21.82**
8	Arka Poornima × Arka Kamini	17.59 **	15.79 **	15.79 **	27.53 **	18.48 **	38.07 **	8.19**	12.71**	12.71**
9	P.G. Purple × AAC-1	17.89 **	14.29 **	47.37 **	-5.79 **	-6.08 **	23.98 **	7.51**	7.57**	31.42**
10	P.G. Purple × Arka Kamini	28.73 **	17.54 **	42.28 **	3.56	-8.99 **	20.14 **	14.07**	26.80**	26.80**
	S.Em ±	0.55	0.63	0.63	0.06	0.07	0.07	0.11	0.13	0.13
	C.D at 5%	1.16	1.34	1.34	0.14	0.16	0.16	0.24	0.28	0.28
	C.D at 1%	1.59	1.83	1.83	0.19	0.22	0.22	0.33	0.38	0.38

*Significant at 5 per cent level ** Significant at 1 per cent level
MP- Mid parent BP- Better parent SC Standard check (Arka Kamini)

Table 4: Estimates of heterosis (%) for number of flowers per plant, yield per plant, yield per hectare and vase life

Sl. No	Crosses	Number of flowers per plant			Yield per plant (g)			Yield per hectare (t)			Vase life (days)		
		MP	BP	SC	MP	BP	SC	MP	BP	SC	MP	BP	SC
1	Namdhari Pink × AAC-1	2.35	-3.67	16.39 **	-2.68	-14.98**	36.24**	-4.66**	-17.43**	34.40**	-0.97	-3.79	17.05**
2	Namdhari Pink × Arka Kamini	6.97**	3.65	10.51 **	15.58**	5.91*	27.18**	15.21**	5.95*	26.25**	5.15*	-1.61	12.90**
3	Namdhari White × AAC-1	2.09	-2.92	17.30 **	17.41**	5.39**	69.38**	18.64**	5.48**	71.69**	7.49**	6.06**	29.03**
4	Namdhari White × Arka Kamini	6.81 **	2.41	11.59 **	39.37**	24.20**	58.75**	38.86**	24.24**	57.37**	15.19**	6.23**	25.81**
5	Miraj Local × AAC-1	1.84	-0.60	20.11 **	22.13**	20.21**	93.20**	21.80**	18.81**	93.39**	5.32**	2.14	32.26**
6	Miraj Local × Arka Kamini	16.85 **	9.21 **	25.63 **	26.30**	3.72	61.45**	26.62**	4.22*	61.29**	12.85**	0.00	29.49**
7	Arka Poornima × AAC-1	10.34 **	-2.40	17.93 **	31.33**	10.20**	77.11**	29.75**	8.31**	76.29**	14.01**	12.50**	36.87**
8	Arka Poornima × Arka Kamini	10.99 **	7.07 **	7.07 **	44.07**	38.13**	50.56**	42.55**	36.68**	48.95**	19.83**	10.51**	30.88**
9	P.G. Purple × AAC-1	4.29 **	-3.21	36.59 **	-3.14*	-10.62**	69.88**	-3.88**	-10.68**	69.35**	10.51**	5.90**	40.55**
10	P.G. Purple × Arka Kamini	19.91**	2.44	44.57 **	22.01**	-6.90**	76.95**	21.93**	-6.88**	76.56**	16.40**	2.05	35.44**
	S.Em ±	0.70	0.81	0.81	2.48	2.87	2.87	0.25	0.29	0.29	0.14	0.16	0.16
	C.D at 5%	1.49	1.72	1.72	5.22	6.03	6.03	0.53	0.61	0.61	0.30	0.34	0.34
	C.D at 1%	2.04	2.35	2.35	7.15	8.26	8.26	0.72	0.83	0.83	0.41	0.47	0.47

*Significant at 5 per cent level ** Significant at 1 per cent level
MP- Mid parent BP- Better parent SC- Standard check (Arka Kamini)

Conclusion

From the present investigation it is concluded that, Miraj Local x AAC-1 and P.G. Purple x Arka Kamini were the top most hybrids with respect to yield potentiality. Namdhari Pink x Arka Kamini and Arka Poornima x AAC-1 found promising for early flowering. Heterosis can be exploited for vegetative, flowering, quality and yield related traits by selecting the appropriate cross combinations in China aster. Since, these are the essential traits which directly or indirectly affect the production potential of the crop, therefore, emphasis may be given on development of F_1 hybrids with improved flower quality and yield in China aster.

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