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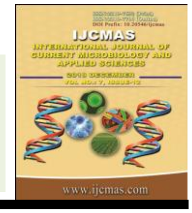

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Estimation of Relative Heterosis in F_1 Hybrids of China Aster [*Callistephus chinensis* (L.) Nees]

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Heterosis over mid parent was estimated in thirty crosses of China aster involving six lines viz., Matsumoto Pink, Matsumoto Red, Matsumoto Rose, Matsumoto Yellow, Matsumoto Scarlet and Matsumoto White and five testers viz., Phule Ganesh Violet, Phule Ganesh Purple, IIHRJ3-2, IIHRG13 and Local White during 2016-17 at ICAR-Indian Institute of Horticultural Research, Bengaluru. Results revealed that the cross L5 × T1 exhibited highest positive significant relative heterosis for plant height, number of branches per plant, and duration of flowering. The cross L5 x T3 exhibited maximum negative relative heterosis for days to first flowering, however, the cross L5 x T4 recorded the maximum positive relative heterosis for flower head diameter and 100 flower weight. The cross L6 x T5 recorded the maximum relative heterosis for flower yield per plant and flower yield per hectare.

Introduction

China aster belongs to the family Asteraceae and is native of Northern China (Navalinskien *et al*., 2005). It is one of the most popular annual flower crops cultivated widely due to existing of various colours ranging from violet, purple, magenta, pink and white; forms, sizes and comparatively longer vase life (Dilta *et al*., 2007). It is grown commercially as cut flower for flower arrangement, interior decoration and loose flower garland making, worshipping (Munikrishnappa, 2013). It can also be grown as bedding plant and potted plant in landscaping (Bhargav *et al*., 2016). China aster is commercially grown by marginal and small farmers in Karnataka, Tamil Nadu, Telangana, Andhra Pradesh, Maharashtra and West Bengal (Kumari *et al*., 2017). In Karnataka alone, it is grown in an area of 1693 ha with productivity of 9.39 t/ha (Anon., 2016).

However, information on heterosis is meager in China aster. Exploitation of heterosis proved to be most viable method of breeding in increasing productivity and the production. The hybrids have various 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. Hence, the present study was carry out to estimate relative heterosis in 30 crosses for vegetative, flowering, yield and vase life traits in China aster.

Materials and Methods

An experiment was carried out in the Floriculture and Medicinal Crops, ICAR-Indian Institute of Horticultural Research, Hesaraghatta, Bengaluru, India during 2016-17. The experimental site was geographically located at 13^o 58' N Latitude, 78^{o}E Longitude and at an elevation of 890 m above mean sea level. A total of 30 F_1 hybrids were developed through crossing in Line x Tester mating design (Table 1); six lines *viz*., Matsumoto Pink, Matsumoto Red, Matsumoto Rose, Matsumoto Yellow, Matsumoto Scarlet and Matsumoto White, and 5 testers *viz*., Phule Ganesh Violet, Phule Ganesh Purple, IIHRJ3-2, IIHRG13 and Local White were used for crossing. The experiment was laid out in randomized complete block design with two replication with 20 plants in each replication were planted at a spacing of 25 x 25 cm under open field conditions. Five random plants per replication were selected for recording observations on plant height (cm), number of leaves per plant, plant spread (cm), number of branches per plant, days to first flowering, flower stalk length (cm), flower head diameter (cm), 100 flowers weight (g), number of flowers per plant, weight of flowers per plant (g), duration of flowering (days) and vase life (days). The standard agronomical practices were adopted during the cropping period.

All statistical analysis were performed using WINDOSTAT version 8.6 (statistical software developed by Indostat Services, Hyderabad) licensed to LAN Indian Institute of Horticultural Research, Hessaraghatta, Bangalore. Data were uniformly recorded and subjected to analysis of variance (Singh and Chaudhary, 1985). Relative heterosis was estimated using the formula (Hallauer and Mirinda, 1988):

$$\text{Relative heterosis (\%)} = \frac{F_1 - MP}{MP} \times 100$$

where,
F_1 = Mean of F_1 hybrid; MP = Value of mid parent

Results and Discussion

Relative heterosis estimates in 30 crosses for vegetative traits are presented in Table 2. Plant height is a significant character which determines the utility of the hybrid. Taller plants with longer stalks are preferred for cut flowers, whereas shorter ones are selected for loose flower, landscaping and pot culture. For plant height, relative heterosis ranged from -21.23 (L4 x T4) to 74.38 (L5 x T1). Among 30 crosses, 20 crosses showed significant positive relative heterosis and two crosses showed significant negative relative heterosis. The cross L5 x T1 exhibited highly significant positive relative heterosis followed by L6 x T5 and L2 x T3. Panwar *et al*., (2013) observed both significantly negative and positive relative heterosis for plant height in marigold. The relative herterosis for number of leaves per plant ranged from -13.76 (L2 x T2) to 45.23 (L1 x T4). Out of 30 crosses, 17 showed positive significant relative heterosis and 3 crosses showed significant negative relative heterosis. The highest relative heterosis was recorded in L1 x T4.

Plant spread is another trait which decides the utility of the crop. Erect plants are generally suitable for cut flowers, however, spreading types for bedding and pot purpose. The relative heterosis for spread ranged from -11.80 (L6 x T4) to 81.84 (L1 x T5); out of 30 crosses, 18 crosses have shown significantly positive relative heterosis, L1 x T5 displayed highest significant positive relative heterosis followed by L6 x T5 and L6 x T1. Relative heterosis for more number of branches per plant is desirable as more branches produces more number of flowers per plant. For number of branches, relative heterosis varied from -47.63 (L5 x T2) to 55.81 (L5 x T1). Among the 30 crosses, only 5 hybrids have shown significant positive relative heterosis. The cross, L5 x T1 identified as the best, followed by L2 x T3. Kumari *et al.,* (2018) reported good amount of relative heterosis for number of branches per plant in China aster.

Relative heterosis estimates in 30 crosses for flowering, flower quality, flower yield and vase life are presented in Table 3. Days to first flowering is a negative trait as earliness is preferred over lateness. Plant earliness is an important character, which helps farmers to fetch more price in early market. Relative heterosis for this trait varied from -34.86 (L5 x T3) to 11.44 (L5 x T4). Among 30 crosses, 24 crosses showed significantly negative relative heterosis and cross L5 x T3 recorded the earliest followed by L1 x T3 and L1 x T2. Kumari *et al.,* (2018) have also reported earliness in China aster hybrids.

Flower stalk length and flower head diameter are decisive traits for selection of a genotype for commercial cultivation. Flowers with long stalk can be used for cut flowers and short stalks for loose flowers. Relative heterosis for flower stalk length ranged from -27.43 (L3 x T4) to 95.03 (L6 x T5). Among 30 crosses, 19 crosses showed significant positive relative heterosis. The cross L6 x T5 exhibited the best.

Flower head diameter is an important character for selecting a hybrid. Relative heterosis for this trait ranged from 8.42 (L3 x T3) to 50.63 (L5 x T4). All the 30 have shown significant positive relative heterosis and cross L5 x T4 displayed the best relative heterosis followed by L6 x T1 and L4 x T4.

One-hundred flowers weight, number of flowers per plant and weight of flowers per plant are contributed directly to flower yield. The relative heterosis for 100 flower weight ranged from -36.65 (L4 x T2) to 20.01 (L5 x T4). Among 30 crosses, only 4 crosses showed significant positive relative heterosis and L5 x T4 exhibited highest significant positive relative heterosis. For number of flowers per plant, relative heterosis varied from -60.88 (L5 x T2) to 108.79 (L6 x T5). Among the crosses, 6 crosses showed significant positive relative heterosis and 10 crosses showed significant negative relative heterosis. The highest significantly positive relative heterosis was recorded in the cross L6 x T5 followed by L5 x T5 and L5 x T1.

The duration of flowering is important trait for the varieties used in landscape garden and commercial cultivation as it facilitates extended number of pickings. For duration of flowering, relative heterosis ranged from -37.15 (L4 x T4) to 63.94 (L5 x T1). Among 30 crosses, 14 crosses exhibited significantly positive relative heterosis and 6 crosses exhibited significantly negative relative heterosis. The cross L5 x T1 recorded highest positive relative heterosis followed by L4 x T2 and L3 x T1.

For weight of flowers per plant, relative heterosis ranged from -75.05 (L5 x T2) to 59.67 (L6 x T5). Among 30 crosses, 5 crosses recorded positive significant relative heterosis and 21 crosses showed significantly negative relative heterosis. The cross L6 x T5 exhibited highly significant positive relative heterosis followed by L5 x T5, L2 x T3, L5 x T4 and L5 x T1. Since, the crosses made between the divergent parents, hence, negative relative heterosis were observed in most of the cross combinations for 100 flowers weight, number of flowers/plant and weight of flowers/plant.

Table.1 Cross combinations of lines (L) x testers (T) evaluated for relative heterosis

Sl. No.	Cross	Cross combination
1.	L1 × T1	Matsumoto Pink x Phule Ganesh Violet
2.	L1 × T2	Matsumoto Pink x Phule Ganesh Purple
3.	L1 × T3	Matsumoto Pink x IIHRJ3-2
4.	L1 × T4	Matsumoto Pink x IIHRG13
5.	L1 × T5	Matsumoto Pink x Local White
6.	L2 × T1	Matsumoto Red x Phule Ganesh Violet
7.	L2 × T2	Matsumoto Red x Phule Ganesh Purple
8.	L2 × T3	Matsumoto Red x IIHRJ3-2
9.	L2 × T4	Matsumoto Red x IIHRG13
10.	L2 × T5	Matsumoto Red x Local White
11.	L3 × T1	Matsumoto Rose x Phule Ganesh Violet
12.	L3 × T2	Matsumoto Rose x Phule Ganesh Purple
13.	L3 × T3	Matsumoto Rose x IIHRJ3-2
14.	L3 × T4	Matsumoto Rose x IIHRG13
15.	L3 × T5	Matsumoto Rose x Local White
16.	L4 × T1	Matsumoto Yellow x Phule Ganesh Violet
17.	L4 × T2	Matsumoto Yellow x Phule Ganesh Purple
18.	L4 × T3	Matsumoto Yellow x IIHRJ3-2
19.	L4 × T4	Matsumoto Yellow x IIHRG13
20.	L4 × T5	Matsumoto Yellow x Local White
21.	L5 × T1	Matsumoto Scarlet x Phule Ganesh Violet
22.	L5 × T2	Matsumoto Scarlet x Phule Ganesh Purple
23.	L5 × T3	Matsumoto Scarlet x IIHRJ3-2
24.	L5 × T4	Matsumoto Scarlet x IIHRG13
25.	L5 × T5	Matsumoto Scarlet x Local White
26.	L6 × T1	Matsumoto White x Phule Ganesh Violet
27.	L6 × T2	Matsumoto White x Phule Ganesh Purple
28.	L6 × T3	Matsumoto White x IIHRJ3-2
29.	L6 × T4	Matsumoto White x IIHRG13
30.	L6 × T5	Matsumoto White x Local White

Table.2 Estimates of relative heterosis in China aster for vegetative traits

Sl. No.	Cross	Plant height (cm)	Number of leaves/plant	Plant spread (cm)	Number of branches/plant
1.	L1 × T1	23.07**	2.94	1.44	7.46
2.	L1 × T2	4.21	-3.89	15.81**	-16.65
3.	L1 ×T3	28.02**	14.10*	6.54	-8.19
4.	L1 ×T4	25.20**	45.23**	14.38*	29.91*
5.	L1 ×T5	21.00**	-6.09	81.84**	26.37
6.	L2 × T1	-10.20*	9.07	3.05	10.62
7.	L2 × T2	17.13**	-13.76*	20.37**	-7.68
8.	L2 ×T3	54.59**	30.51**	17.16**	55.00**
9.	L2 ×T4	-8.37	23.53**	-8.58	-4.97
10.	L2 ×T5	17.03**	3.83	30.06**	10.03
11.	L3 × T1	-0.57	-4.48	7.95	-24.99*
12.	L3 × T2	10.30*	-11.35*	30.82**	-16.57
13.	L3 ×T3	30.58**	34.08**	19.60**	-2.50
14.	L3 ×T4	3.74	15.33*	-1.21	-1.33
15.	L3 ×T5	24.00**	17.58**	48.97**	14.29
16.	L4 × T1	20.46**	19.66**	33.43**	-1.75
17.	L4 × T2	21.15**	-10.06	29.45**	-29.03**
18.	L4 ×T3	2.27	30.74**	3.31	-19.40*
19.	L4 ×T4	-21.23**	23.47**	6.75	-33.87**
20.	L4 ×T5	-9.42	13.95*	33.63**	-2.43
21.	L5 × T1	74.38**	42.48**	32.10**	55.81**
22.	L5 × T2	-6.65	-11.81	-8.50	-47.63**
23.	L5 ×T3	37.38**	43.73**	13.29*	43.76**
24.	L5 ×T4	33.58**	-11.06	13.23*	-26.06*
25.	L5 ×T5	49.67**	28.87**	61.21**	33.33**
26.	L6 × T1	29.15**	-5.45	71.97**	0.86
27.	L6 × T2	14.00**	-6.00	-1.53	-33.84**
28.	L6 ×T3	36.77**	22.07**	8.30	6.85
29.	L6 ×T4	-1.63	36.67**	-11.80	7.01
30.	L6 ×T5	62.90**	36.36**	73.85**	17.54
	SEm ±	1.47	1.27	1.05	0.98
	C.D. (P=0.05)	3.00	2.60	2.14	2.01
	C.D. (P=0.01)	4.05	3.50	2.89	2.71

Table.3 Estimates of relative heterosis in China aster for flowering, flower yield and vase life

Sl. No.	Cross	Days to first flowering	Flower stalk length (cm)	Flower head diameter (cm)	100 flower weight (g)	Number of flowers/ plant	Duration of flowering (days)	Weight of flowers/plant (g)	Flower yield/ hectare (q)	Vase life (days)
1.	L1 × T1	-24.58 **	-4.75	23.78**	-26.43 **	17.18*	40.14**	-26.05**	-26.04**	-21.07 **
2.	L1 × T2	-30.35 **	6.56	36.00**	-17.67 **	-15.63*	4.96	-41.67**	-41.67**	-26.85 **
3.	L1 ×T3	-33.90 **	-8.87	16.00**	-10.06 **	-11.58	-15.59*	-26.22**	-26.22**	-28.57 **
4.	L1 ×T4	-25.57 **	14.44*	26.72**	-13.14 **	-11.75	-11.86	-28.79**	-28.80**	-9.13**
5.	L1 ×T5	-21.05 **	26.38**	30.11**	-4.84 **	-20.02*	-14.74*	-27.32**	-27.30**	-29.71 **
6.	L2 × T1	-8.11 **	-3.07	19.05**	-26.15 **	-25.25**	6.38	-51.80**	-51.80**	-22.25 **
7.	L2 × T2	-15.00 **	28.06**	12.59**	-32.05 **	5.58	26.07**	-38.73**	-38.73**	-17.92 **
8.	L2 ×T3	-23.75 **	21.54**	14.94**	3.08**	49.38**	36.89**	44.58**	44.57**	0.00
9.	L2 ×T4	7.92**	-18.08**	15.14**	-4.81 **	-21.92**	-7.37	-30.17**	-30.17**	-23.79 **
10.	L2 ×T5	-2.08	26.66**	26.83**	3.32**	-2.79	22.99**	-3.02	-3.01	-20.02 **
11.	L3 × T1	-9.83 **	32.23**	13.70**	-27.68 **	-32.22**	58.04**	-56.78**	-56.78**	-20.54 **
12.	L3 × T2	-24.72 **	26.42**	14.33**	-25.71 **	-15.14*	8.21	-45.61**	-45.60**	-23.36 **
13.	L3 ×T3	-28.57 **	19.08**	8.42*	-12.90 **	6.80	18.05*	-12.09	-12.09	-6.98*
14.	L3 ×T4	-12.19 **	-27.43**	15.57**	-16.04 **	-41.04**	-0.41	-53.18 **	-53.17**	2.20
15.	L3 ×T5	-15.78 **	47.29**	21.14**	-12.43 **	12.09	44.01**	-4.66	-4.66	5.25
16.	L4 × T1	-20.42 **	32.45**	30.04**	-32.12 **	-4.74	5.16	-39.08**	-39.08**	-5.29
17.	L4 × T2	-24.93 **	28.05**	27.62**	-36.65 **	-9.39	61.70**	-47.36**	-47.36**	-36.58 **
18.	L4 ×T3	-28.46 **	5.20	14.92**	-13.51 **	-12.76*	-18.49**	-26.17**	-26.17**	0.00
19.	L4 ×T4	-19.61 **	0.53	41.49**	7.93**	-51.55**	-37.15**	-49.33 **	-49.33**	-36.40 **
20.	L4 ×T5	-24.56 **	30.55**	27.82**	-23.06 **	-11.44	-17.18**	-31.08 **	-31.09**	-13.25 **
21.	L5 × T1	-23.75 **	14.24*	30.33**	-19.36 **	58.00**	63.94**	10.45*	10.46*	-5.58
22.	L5 × T2	-22.37 **	3.01	14.96**	-24.85 **	-60.88**	-16.69*	-75.05 **	-75.06**	-23.08 **
23.	L5 ×T3	-34.86 **	12.77	18.85**	-3.81 **	3.91	10.13	-6.62	-6.63	15.00**
24.	L5 ×T4	11.44 **	25.70**	50.63**	20.01 **	7.40	16.27*	20.41**	20.40**	19.07**
25.	L5 ×T5	-19.34 **	91.26**	36.19**	0.77	61.22**	21.55**	56.15**	56.16**	25.76**
26.	L6 × T1	9.11 **	38.75**	43.94**	-20.96 **	18.16**	31.42**	-11.49**	-11.48**	48.50**
27.	L6 × T2	8.99 **	36.45**	19.90**	-25.37 **	-5.30	41.03**	-34.60**	-34.60**	0.00
28.	L6 ×T3	-11.24 **	22.56**	16.92**	-20.23 **	0.01	5.88	-21.48**	-21.48**	-12.85 **
29.	L6 ×T4	-3.68 **	-14.89*	21.51**	-22.02 **	1.39	9.88	-22.51**	-22.52**	-2.49
30.	L6 ×T5	-0.75	95.03**	25.18**	-23.88 **	108.79**	49.71**	59.67**	59.67**	-17.69 **
	SEm ±	0.69	1.55	0.14	1.87	1.38	1.35	2.80	2.35	0.19
	C.D. (P=0.05)	1.41	3.16	0.28	3.82	2.82	2.77	5.73	4.81	0.38
	C.D. (P=0.01)	1.90	4.26	0.38	5.14	3.80	3.73	7.72	6.48	0.51

The results are in accordance with the findings of Pavani (2014) and Kumari *et al.*, (2018) in China aster.

Flower yield is the most important trait for commercial cultivation of China aster. Varieties with good quality character along with good yield are always be preferred by growers. The relative heterosis ranged from -75.06 (L5 x T2) to 59.67 (L6 x T5). Among 30 crosses, only 5 crosses showed significantly positive relative heterosis. The cross L6 x T5 recorded the best for relative heterosis, followed by L5 x T5 and L2 x T3. Panwar *et al.*, (2013) also observed significantly negative and positive relative heterosis for duration of flowering and flower yield per hectare in marigold, and Kumari *et al.*, (2018) in China aster.

Vase life is an important postharvest trait for cut flower. Relative heterosis for this trait ranged from -36.58 (L4 x T2) to 48.50 (L6 x T1). Out of 30 crosses, four crosses showed significantly positive heterosis and 18 showed significantly negative. The cross L6 x T1 exhibited highly significant positive relative heterosis followed by L5 x T5, L5 x T4 and L5 x T3.

In conclusion, relative heterosis can be exploited for vegetative, flowering, flower quality, yield related traits and vase life by selecting the appropriate cross combinations. The cross L5 × T1 exhibited highest positive significant relative heterosis for plant height, number of branches per plant and duration of flowering. The cross L5 x T3 exhibited maximum negative relative heterosis for days to first flowering, however, the cross L5 x T4 recorded the maximum positive relative heterosis for flower head diameter and 100 flower weight. The cross L6 x T5 recorded the maximum relative heterosis for flower yield per plant and flower yield per hectare. These cross combinations can be selected based on the trait requirement for exploitation of heterosis.

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