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Heterobeltiosis in African marigold (*Tagetes erecta* L.)

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Abstract

A line × tester crossing programme was taken up with three male sterile lines viz., ms_7, ms_8 and ms_{12} and a set of 11 diverse pollinators such as selections 7, 8, 14, 19, 21, 22, 27, 28, 29, 31 and 56 used as testers. The hybrids (33 F_1s) along with parents were evaluated during 1995-96 (winter) and 1996 (summer) in randomized block design with three replications. Detailed observations on 12 and 10 characters during winter and summer respectively showed that F_1s were much better than the mean performance of the parents during both the seasons. Appreciable heterosis was observed in all the characters except in two.

Key words : Marigold, ms line, hybrid, heterbeltiosis

Introduction

The African marigold (*Tagetes erecta* L.) is grown as a commercial flower crop throughout India. According to a survey conducted during 1987 by the Indian Institute of Management, Ahmedabad, marigolds are cultivated in an area of about 1,500 hectares producing nearly 11,500 tons of flowers annually in the country [1]. Marigolds, in India, are used commonly for making garlands for religious and social functions, as a cut flower, and in gardens for beautification in beds and borders. The pigments extracted from petals are in great demand for poultry feeding. In addition, marigolds are highly effective in keeping the nematodes population in soil under control. Presently, mostly open pollinated varieties are grown which are less vigorous, uneven in height and with low yield. Keeping in view of the importance of marigolds, a study was planned to generate information for exploitation of heterotic vigour using male sterility.

Materials and methods

The present investigation was carried out with three male sterile lines viz. ms_7, ms_8 and ms_2 crossed with a set of 11 diverse pollinators namely selections 7, 8, 14, 19, 21, 22, 27, 28, 29, 31 and 56. Three male sterile lines ms_7, ms_8 and ms_{12} were obtained from the selfing of F_1 seeds of marigold purchased from M/s. Sutton's India Limited. The crossed seeds thus obtained were grown during the winter 1995-96 and summer 1996 to raise F_1 hybrids, which were evaluated along with parental lines in randomized block design with three replications. The spacing between rows and between plants within a row was kept 45 cm. Basal dose of N:P:K @ 12g, 8g and 8g, respectively per square meter was applied at the time of planting alongwith foliar application of urea (0.1%) given after one month of transplanting of seedlings. Five plants excluding the border ones, in each plot were selected at random for taking data. The average minimum and maximum temperatures after transplanting during winter crop from November, 1995 to April, 1996 were 11.3°C and 26.3°C, respectively and during summer crop from March, 1996 to July, 1996, were 21.9° and 35.7°, respectively. Observations were recorded on twelve characters. It may be mentioned here that during summer crop, Selection 7 did not flower but its three hybrids (ms_7 × Sel7, ms8 × Sel7 and ms_{12} × Sel7) flowered. No seed was set in any of the genotypes in summer since the environmental conditions in the two sesons were striking by diverse. The data were thus separately considered for the two crops (without pooling together). The magnitude of heterosis as the difference in F_1 performance over better parent (heterobeltiosis) in percentage was calculated as per Hayes *et al.* [2].

Results and discussion

Analysis of variance performed for the design of experiment revealed that genotypic differences were highly significant for all the characters during both the crop seasons, except for seed number per head during winter.

During winter crop (Table 1), differences among parents were found highly significant for all the

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Table 1. Heterosis percentage over better parent in marigold for twelve characters during winter 1996-97

Traits / Cross	Days to flowering	Plant height (cm)	Plant spread (cm)	No. of flowers/plant	Weight of flower (g)	Flower size (cm)	Stak length (cm)	Duration of flowering	Flower yield (g)	Harvest index	No. of seeds/head	1000 seeds wt. (g)
$MS_7 \times$Sel. 7	–24.6**	20.0**	17.4	63.2	101.0**	16.8	12.7	414**	68.7	26.1**	4.8	3.1
$MS_7 \times$Sel. 8	–28.6**	13.3	21.7	77.9	115.2**	24.3**	31.8	1.7	135.5**	7.9	8.0	33.0
$MS_7 \times$Sel. 14	–25.7**	31.1**	19.9	62.3	145.0**	36.5**	–14.1	23.1	189.8**	6.0	–8.5	–1.3
$MS_7 \times$Sel. 19	–34.2**	12.5	24.3	83.8**	125.0**	23.4**	45.9	20.6	152.3**	6.0	12.2	1.1
$MS_7 \times$Sel. 21	–12.3	22.9**	12.1	85.7**	124.3**	6.6	20.3	16.7	131.4**	13.2	7.8	10.1
$MS_7 \times$Sel. 22	–28.2**	5.6	2.7	68.9	124.6**	12.9	31.6	17.8	75.7	14.7	3.1	–1.2
$MS_7 \times$Sel. 27	–6.7	28.7**	17.8	80.0	140.7**	12.4	33.3	29.1**	129.8**	24.3**	10.9	36.3**
$MS_7 \times$Sel. 28	–4.8	16.8**	20.5	79.8	125.5**	9.4	3.9	9.7	103.0*	16.7**	2.7	15.9
$MS_7 \times$Sel. 29	–7.6	27.4**	27.2**	90.8**	146.5**	26.3**	–1.1	19.2	157.4**	26.3**	13.3	47.9**
$MS_7 \times$Sel. 31	–13.5**	10.7	26.1**	124.6**	106.9**	13.7	8.9	31.9**	281.4**	38.8**	6.1	34.0
$MS_7 \times$Sel. 56	–12.8	21.0**	38.0**	91.8**	141.9**	26.6	0.2	43.9**	125.9*	24.4**	10.7	0.1
$MS_8 \times$Sel. 7	–39.2**	–0.3	14.3	126.1**	180.8**	31.9	21.6	25.9**	310.2**	35.4**	16.7	11.8
$MS_8 \times$Sel. 8	–6.2	19.4**	13.8	150.4**	180.8**	31.9	21.6	25.9**	310.2**	35.3**	16.7	11 8
$MS_8 \times$Sel. 14	–26.0**	16.9**	17.5	63.7	141.8**	52.7**	–11.9	15.6	223.8**	7.8	4.6	52 7**
$MS_8 \times$Sel. 19	–1.7	8.9	8.9	67.8	125.2**	30.9**	13.3	3.3	143.4**	10.9	10.1	23.3
$MS_8 \times$Sel. 21	–5.6	2.1	14.5	83.2**	141.3**	30.8**	17.9	17.6	134.3**	18.8**	21.2	–9.1
$MS_8 \times$Sel. 22	–26.5**	1.7	2.1	73.9	157.7**	33.3**	–1.6	34.6**	134.2**	17.3**	9.4	26.5
$MS_8 \times$Sel. 27	–10.4	9.8**	11.7	112.4**	162.4**	14.9	33.7	27.4	216.3**	25.6**	16.6	31.8
$MS_8 \times$Sel. 28	–2.5	–0.2	13.6	112.7**	121.3**	15.6	–18.3	8.0	266.9**	25.4**	9.1	24.1
$MS_8 \times$Sel. 29	–1.7	–5.7	10.3	67.0	162.1**	34.4**	–7.5	0.2	129.2**	22.2**	9.4	33.7
$MS_8 \times$Sel. 31	–12.1**	4.5	7.3	111.8**	143.1**	18.3	–2.4	18.9	301.3**	27.0**	15.6	20.5
$MS_8 \times$Sel. 56	–25.2**	14.2**	3.1	88.8**	100.5**	39.4*	25.9	42.5**	118.9*	13.6	30.6	16.3
$MS_{12} \times$Sel. 7	–28.9**	6.2	24.8**	112.7**	116.7**	21.1**	1.4	42.2**	130.7**	55.8**	22.9	–4.5
$MS_{12} \times$Sel. 8	–26.8**	12.1	3.3	64.7	74.6**	7.6	10.9	9.3	213.2**	24.7**	7.3	41.6**
$MS_{12} \times$Sel. 14	–2.3	9.3	0.8	49.4	48.4	16.2	–6.2	9.9	154.5**	27.8**	26.6	31.1
$MS_{12} \times$Sel. 19	29.8**	10.1	–2.0	61.5	55.7	17.5	–17.7	6.0	88.9	17.8**	26.6	31.1
$MS_{12} \times$Sel. 21	–28.1**	22.2**	7.6	56.6	107.1**	–3.7	–6.6	11.5	121.5*	9.6	32.4	25.9
$MS_{12} \times$Sel. 22	–27.7**	16.3**	11.8	69.3	50.6	4.8	1.4	36.1**	160.6**	28.0**	9.2	–9.3
$MS_{12} \times$Sel. 27	–8.6	19.3**	1.9	42.7	54.7	12.3	13.3	15.1	126.9*	32.0**	16.3	26.1
$MS_{12} \times$Sel. 28	–26.5**	23.1**	7.7	66.7	64.0**	9.4	–5.5	8.1	130.4**	17.6**	14.6	30.9
$MS_{12} \times$Sel. 29	–10.9**	18.8**	–8.9	13.4	51.6	23.1**	–5.4	15.1	36.3	1.0	27.4	9.5
$MS_{12} \times$Sel. 31	–17.2**	–4.9	15.8	56.7	64.7**	7.4	–7.1	26.2	201.1**	40.0**	25.8	7.4
$MS_{12} \times$Sel. 56	–13.8**	–17.2**	7.7	49.9	85.4**	9.0	12.8	38.6**	50.2	11.1	17.8	–2.4

* - Significant at 5% level of significance
** - Significant at 1% level of significance

characters, except for flower number, flower weight and seed number. During summer crop (Table 2), parental differences were highly significant for all the characters, except for flower weight and flower yield. In case of hybrids also, differences were highly significant for all the traits, except for flower weight. However, parents/hybrids variances were highly significant for all the characters in both the seasons.

Highly significant parents/hybrids variances for 1000 seed weight during winter crop and for all the remaining 10 characters during both the seasons confirmed that these traits were controlled by different genes in male and female lines and hence produced entirely different range in the respective traits. When brought together in the various combinations in F_1 hybrids, they gave significant heterosis for all the traits during both the crop seasons.

Appreciable heterosis was observed in all the characters, except for stalk, length and number of seeds per head during winter. The highest heterosis was obtained in flower yield which was 310.2% for winter crop and 535.7% for summer crop. During winter, 28 hybrids out of 33 and during summer 21 hybrids out of 30 showed significant heterosis. During winter, F_1 hybrid ms8 × Sel 8 and during summer ms8 × Sel 31 recorded highest percentage of heterosis. Reddy *et al.* [3] and Kumar *et al.* [4] reported highest heterosis of 53.3 and 748.5 per cent, respectively for flower yield.

Table 2. Heterosis percentage over better parent in marigold hybrids for ten characters during summer 1996

Cross	Days to flowering	Plant height (cm)	Plant spread (cm)	No. of flowers/ plant	Height of flower(g)	Flower size (cm)	Stalk length (cm)	Stalk length (cm)	Duration of flowering	Flower yield (g)
MS_7×Sel. 8	–23.3**	17.9**	4.2	146.7**	60.6**	48.8**	15.9	47.6**	215.8**	50.5**
MS_7×Sel. 14	–20.6**	34.6**	23.8	110.4**	11.0	42.8**	42.9**	97.6**	78.8	55.5**
MS_7×Sel. 19	–26.9**	15.9**	37.6**	30.5	11.3	22.4	8.4	49.0**	154.5**	44.4**
MS_7×Sel. 21	–40.8**	28.0**	13.5	43.6**	16.6	27.7**	0.0	43.3**	69.5	28.8**
MS_7×Sel. 22	–28.0**	7.4	–6.6	50.0**	1.7.8**	23.5	14.1	39.1**	205.4**	37.4**
MS_7×Sel. 27	–27.4**	31.3**	27.8**	41.8**	81.5**	10.9	–7.9	42.4**	170.1**	21.2**
MS_7×Sel. 28	–31.9**	32.6**	39.5**	56.8**	22.1	13.7	1.0	42.7**	104.2	5.9
MS_7×Sel. 29	–23.1**	28.4**	16.6	41.4	42.5	21.5	35.9	45.3**	122.5	13.4
MS_7×Sel. 31	–27.3**	14.7**	22.8	33.3	63.0**	31.0**	25.4	47.3**	166.4**	17.4**
MS_7×Sel. 56	–26.0**	25.3**	15.4	46.9**	30.5	25.0	–0.9	45.3**	133.0*	23.6**
MS_8×Sel. 8	–36.7**	25.6**	33.5**	198.4**	37.1	44.4**	9.4	55.5**	305.1**	49.4**
MS_8×Sel. 14	–21.9**	26.8**	26.3**	158.3**	7.4	23.4	20.8	55.8**	197.3**	65.0**
MS_8×Sel. 19	–33.7**	15.9**	32.4**	69.1**	–1.9	23.1	7.0	56.6**	113.5**	47.2**
MS_8×Sel. 21	–40.8**	9.3	29.2**	84.8**	31.2	29.2**	–8.9	50.4**	145.3*	30.7**
MS_8×Sel. 22	–29.8**	8.7	21.2**	105.3**	20.1	27.5	1.8	50.8**	174.7**	44.8**
MS_8×Sel. 27	–27.8	16.4**	31.9**	83.9**	76.1**	27.3	–2.4	53.5**	301.2**	24.0**
MS_8×Sel. 28	–32.2**	8.4	22.3	85.3**	83.8**	13.1	0.5	46.1**	331.4**	24.2**
MS_8×Sel. 29	–23.3**	14.8**	28.2**	111.6**	28.2	25.7	–7.8	44.4**	253.3**	18.5**
MS_8×Sel. 31	–25.3**	11.4	19.8	118.1**	91.1*	27.4	5.7	52.3**	535.7**	29.6**
MS_8×Sel. 56	–25.3**	21.8**	20.1	102.6**	36.6	42.4**	6.8	50.2**	269.2**	24.8**
MS_{12}×Sel. 8	–22.9**	9.0	7.4	178.1**	21.7	11.0	1.9	53.8**	209.6**	43.7**
MS_{12}×Sel. 14	–22.9**	8.2	–0.5	103.3**	7.4	14.9	–4.8	52.2**	102.0**	52.9**
MS_{12}×Sel. 19	–20.6**	12.8	13.6	54.6**	4.7	21.1	–7.9	49.0**	84.4	28.1**
MS_{12}×Sel. 21	–24.8**	19.1**	21.3	67.7**	2.1	24.1	–5.3	45.4**	11.7	20.2**
MS_{12}×Sel. 22	27.0**	12.7	24.6**	74.3**	69.4**	16.1	1.9	39.1**	176.5**	44.7**
MS_{12}×Sel. 27	21.9**	16.6**	15.2	70.2**	7.4	–3.0	7.9	45.0**	87.9	10.2
MS_{12}×Sel. 28	22.0**	18.9**	1.1	69.8**	13.6	3.1	3.8	37.1**	107.4	6.4
MS_{12}×Sel. 29	–21.3**	17.2**	–1.4	55.6**	44.7	4.3	–17.9	35.5**	144.7*	7.0
MS_{12}×Sel. 31	25.3**	–3.5	22.9	76.9**	44.5	1.9	–15.6	48.4**	202.2**	16.9
MS_{12}×Sel. 56	–29.7**	–15.5**	25.7**	80.3**	56.9**	21.5	–16.5	48.4**	203.8**	19.4

* Significant at 5% level of significance
** Significant at 1% level of significance

The highest heterosis observed in other traits was –32.2% for plant height, 38% for plant spread, 150.4% for number of flowers per plant, 180.8% for weight of flowers, 52.7% for flower size, 53.3% for duration of flowering, 55.85% for harvest index, 32.4% for number of seeds per head and 52.7% for 1000 seed weight during winter. Singh and Swarup [5] reported highest heterosis of plant height 44.1% and flower weight 171.49% during winter. During summer, the highest heterosis observed for various traits was –40.8% for days taekn to flowering, 34.6% for plant height, 38.0% for plant spread, 198.4% for number of flowers per plant, 107.8% for weight of flower, 48.8% for flower size, 56.6% for durationof flowering and 65.0% for harvest index. In all the characters, the best performing F_1 was better than the better parent. Considering the most important economic character i.e. flower yield during winter, hybrids ms_7 × Sel 29, ms_7 × Sel 56, ms_8 × Sel 7, ms_8 × Sel 8, ms_8 × Sel 27, ms_8 × Sel 28, ms_8 × Sel 56 and ms_{12} × Sel 7 were best heterotic combinations and excelled in flower yields over remaining hybrids while during summer, hybrids ms_7 × Sel 27, ms_8 × Sel 7, ms_8 × Sel 8, ms_8 × Sel 21, ms_8 × Sel 28, ms_8 × Sel 28, ms_8 × Sel 31 and ms_8 × Sel 56 were found best heterotic combinations and showed superiority in flower yield over other hybrids.

Some hybrid combinations viz., ms_8 × Sel 7, ms_8 × Sel 8, ms_8 × Sel 27, ms_8 × Sel 28 and ms_8 × Sel 56 showed wide adaptability and can be cultivated both in winter as well as in summer seasons. These combinations included atleast one top parent for one or more characters. Out of three male sterile lines, ms_8 had highest yielding capability during both the crop seasons, followed by ms_7. Among pollinators, Sel 7, Sel 8, Sel 21, Sel 27, Sel 31 and Sel 56 were the better performing male lines over both the crop seasons having high yield potential. These results advocate that breeding programmes can be confidently initiated to evolve F_1 hybrids in marigold for commercial cultivation during both the seasons (winter and summer). However, efforts should be made to introduce sterility genes in more number of agronomically suitable backgrounds to increase diversity among the male sterile lines.

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