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Research Article

Heterosis and inbreeding depression for seed yield and its contributing characters in safflower (*Carthamus tinctorius* L.)

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Abstract

The present study was conducted in order to develop genetic information on heterosis and inbreeding depression for seed yield and its contributing characters using generation mean analysis in safflower (*Carthamus tinctorius* L.). GMU-2720 x GMU-3423 (Cross-1) depicted a positive and significant relative heterosis, standard heterosis and heterobeltiosis for seed yield per plant. Cross-1 also revealed a significant desirable relative heterosis, standard heterosis and heterobeltiosis for number of others yield contributing traits. Negatively significant inbreeding depression was observed for the characters i.e., the number of branches per plant, the number of capitulum per plant, the number of seeds per capitulum, test weight and seed yield per plant in JMU-1339 x GMU-3423 (Cross -2). It was suggested that the parental genotypes GMU-2720 and GMU-3423 due to their presence in high heterotic combinations *viz.*, GMU-2720 x GMU-3423 would be further exploited in future safflower breeding programme. The cross JMU-1339 x GMU-3423 exhibited a significant negative inbreeding depression for test weight, seed yield per plant and oil content. Hence, this cross would likely to yield beneficial transgressive segregants for these traits leading to the possibility of selecting superior recombinations for high seed yield and high oil content in F_2 and succeeding generations.

Key words

Safflower, heterosis, heterobeltiosis, standard heterosis and inbreeding depression

INTRODUCTION

Safflower is one of the most important oilseed crops. Safflower is basically an autogamous crop but insects especially bees are required for optimum pollination and maximum of yield. Cross pollination generally through bees to the intensity of 10-28 per cent depending on genotype and insect activity had been reported in safflower (Weiss and Gecgall., 2000). Safflower has been gaining reputation in later years in several parts of the country because of its adaptability under drought conditions. The increase in productivity through breeding exercise has not been sufficient because of traditional selection methods following hybridization. Heterosis breeding could be a potential substitute for accomplish quantum jumps in production and productivity. The significant breakthrough in yield approach could be made through using of heterosis at commercial level (Knowles, 1989). The comprehensive review of heterosis in safflower indicated that there would be significant amount of heterosis over commercial cultivars indicating the possibility of exploiting heterosis at commercial level in safflower (Sarode *et al.,* 2008). The using of hybrid vigour as capability to increasing the yields of agricultural crops has become one of the most important technique in plant breeding. The heterosis revealed the superiority of F_1 hybrid over its parents in term of yield and remains traits. Heterosis helps in the recognition of potential cross combinations that to be used in conventional breeding programme to prepare create broad cluster of variability in segregating generations. The knowledge of heterosis followed by the expansion of inbreeding depression in subsequent generations is required for the maximum using of such heterosis by maintain appropriate breeding methodology.

MATERIALS AND METHODS

Three accessions of safflower (*Carthamus tinctorious* L), *viz*., GMU-2720, GMU-3423 and JMU -1339 obtained from AICRP, Parbhani were used in the present study. The experiments involved the six basic generations (P_1, P_2, F_1, F_2, BC_1 and BC_2) of two cross combinations. The combinations used were GMU-2720 x GMU-3423 and JMU-1339 x GMU-3423. The research was conducted at the research farm of Department of Genetics and Plant Breeding, College of Agriculture, Latur during 2019. All the six basic generations, i.e. (P_1, P_2, F_1, F_2, B_1 and B_2) were planted in a RBD with 2 replications and a plot size of 15 x 8 m. The data on quantitative traits viz., days to 50% flowering, days to maturity, plant height (cm), the number of branches per plant , the number of capitulums per plant, the number of seeds per capitulum, test weight (g), seed yield per plant (g), hull content (%) and oil content (%) were reported on 5 randomly selected plants in each of P_1, P_2 and F_1 generations, 5 plants each of B_1 and B_2 and 20 plants of F_2 generations. Heterobeltiosis was measured as the rate of the deviation of the mean value from the better parent value and standard heterosis from the value of standard check. The F_1 hybrids performance was calculated as the heterosis over standard checks and better parent.

RESULTS AND DISCUSSION

The assessment of heterosis was expressed as percentage over mid parent (RH), standard heterosis expressed as percentage over standard check and heterobeltiosis expressed as percentage over better parent (HB) in F_1 hybrids and inbreeding depression in F_2 population for various traits was calculated from two crosses of safflower (**Table 1**). The strength of heterosis diverse from cross-to-cross for all the ten characters were investigated, for characters *viz*., days to 50 per cent flowering, days to maturity, plant height, the number of branches/plant, the number of capitulum/plant, the number of seeds/capitulum, test weight, seed yield/plant, hull content and oil content.

Cross-1 *viz.,* GMU-2720 x GMU-3423 exhibited a negative relative heterosis for days to 50 % flowering and days to maturity and the positive relative heterosis for plant height, and negatively significant for hull content. This indicated an early flowering and maturity, tall plant height and increase oil content which was desirable in F_1 than the mid parental value. Cross-1 showed a significant positive relative heterosis for the number of branches/plant, the number of seeds/capitulum, test weight, seed yield/plant and positive for oil content, which indicated that there was an increased in the number of branches/plant, seed yield/plant and oil content in F_1 than the mid parental value. Cross-2 *viz.,* JMU-1339 x GMU-3423 exhibited a positive relative heterosis for days to 50% flowering, days to maturity, plant height and negatively significant for test weight and hull content indicating the late flowering and maturity, tall plant height, and increased oil content due to negative significant for hull content which was desirable. Cross-2 revealed a significant positive relative heterosis for the number of branches/plant, the number of capitulum/plant, the number of seeds/capitulum, seed yield/plant and oil content, which indicated that there was an increase in the number of branches/plant, the number of capitulum/plant, the number of seeds/capitulum, seed yield/plant and oil content in F_1 than the mid parental value. Patel and Shrivastava. (2016) and Patel *et al*. (2018) also noticed similar results.

GMU-2720 x GMU-3423 exhibited a negative standard heterosis for days to 50% percent flowering, days to maturity and negatively significant for hull content indicating an early flowering and maturity and increased oil content which was desirable in F_1 than the standard check value. GMU-2720 x GMU-3423 showed a positive standard heterosis for the number of branches/plant and test weight, significantly positive standard heterosis for seed yield/plant, the number of seed/capitulum and oil content which were indicated by an increase in the number of branches/plant, the number of seed/capitulum, seed yield/plant and oil content in F_1 than the standard check value. JMU-1339 x GMU-3423 exhibited a significant positive standard heterosis for oil content and negatively significant standard heterosis for hull content which was desirable for these traits. Similar result were observed by Patel *et al*. (2018), Parde *et al*. (2010), Sarode *et al*. (2008), Deedawat *et al*. (2016) and Satpute *et al*. (2011).

Both Crosses exhibited negative heterobeltiosis for days to 50 % flowering, days to maturity and plant height indicating an early flowering, early maturity and dwarf plant height which was desirable in F_1 than the better parent value. GMU-2720 x GMU-3423 negatively significant heterobeltiosis for hull content indicating an increased oil content which was desirable in F_1 than the better parent value. GMU-2720 x GMU-3423 showed a significant positive heterobeltiosis for the number of branches per plant, the number of seeds per capitulum, test weight, seed yield per plant and significantly negative heterobeltiosis for oil content which indicated that there was an increase in the number of branches/plant, the number of seeds per capitulum, test weight, seed yield/plant in F_1 than the better parent value. Related results were recorded by Manjare and Jambhale (1995), Kumar *et al*. (2012), Shivani *et al.* (2011), Deedawat *et al*. (2016), Patel *et al*. (2018), Satpute *et al*. (2011), Sarode *et al*. (2008), Parde *et al.* (2010), Shivani *et al.* (2010) and Patel and Shrivastava (2016).

The assessment of inbreeding depression was found significant but negative for days to 50 % flowering, days to maturity and plant height in all the crosses. Significant negative inbreeding depression in respect of days to 50

Table 1. Estimate of better parent heterosis, mid-parent and standard heterosis over sharda in two crosses of safflower

Crosses	Per cent Heterosis Over			Inbreeding Depression (%)
	Better Parent (%)	Mid-parent (%)	Standard Heterosis (%)	
		Days to 50% Flowering		
GMU-2720 x GMU-3423	-4.42	-1.45	-1.65	-6.33**
JMU-1339 x GMU-3423	-2.18	1.25	1.90	-3.19
		Days to Maturity		
GMU-2720 x GMU-3423	-6.48*	-2.63	-0.59	-8.13**
JMU-1339 x GMU-3423	-3.27*	0.32	4.29*	-1.99
		Plant Height		
GMU-2720 x GMU-3423	-11.93**	3.61	10.09**	-8.61**
JMU-1339 x GMU-3423	-17.88**	2.58	6.96**	-5.51**
		Number of Branches Per Plant		
GMU-2720 x GMU-3423	18.46*	11.59*	3.36	8.92**
JMU-1339 x GMU-3423	15.26	27.42**	1.34	-5.62**
		Number of Capitulums Per Plant		
GMU-2720 x GMU-3423	-0.26	-8.18**	-0.79	20.81**
JMU-1339 x GMU-3423	9.62	27.13**	8.18	14.87**
		Number of Seeds Per Capitulum		
GMU-2720 x GMU-3423	21.64**	50.46**	84.53**	11.09**
JMU-1339 x GMU-3423	-4.18	29.35**	55.47**	-14.56**
		Test Weight		
GMU-2720 x GMU-3423	5.00*	3.70*	2.44	1.19
JMU-1339 x GMU-3423	-12.50**	-2.77	-14.63**	-17.57**
		Seed Yield Per Plant		
GMU-2720 x GMU-3423	11.20**	14.97**	52.27**	19.92**
JMU-1339 x GMU-3423	-23.40*	7.74*	1.14	-7.47**
		Hull Content		
GMU-2720 x GMU-3423	-22.74**	-13.49*	-11.01**	-40.42**
JMU-1339 x GMU-3423	-24.64**	-20.37**	-14.27**	-41.70**
		Oil Content		
GMU-2720 x GMU-3423	-7.51**	1.14	7.96**	0.65
JMU-1339 x GMU-3423	0.12	5.71**	18.22**	-3.74

*Significant at 5% level, ** Significant at 1% level.

per cent flowering and days to maturity was noticed in cross 1 & 2, respectively, indicating thereby that F_2's were late flowering and maturity than their F_1's. For plant height cross 1 and 2 combinations showed significantly negative inbreeding depressions. The superiority of F_2's over their F_1's in case of the number of branches/plant, the number of seeds/capitulum, test weight, seed yield/plant and oil content was observed in cross 2 only. Similar results were reported by Shivani *et al*. (2010), Shivani *et al*. (2011), Patel and Shrivastava (2016) and Patel *et al*. (2018) for these characters.

Thus the cross 1 revealed a high standard heterosis with inbreeding depression for the number of branches/plant, the number of seeds/capitulum, test weight, seed yield/plant and oil content. Cross 1 revealed a high relative heterosis with inbreeding depression for the number of branches/plant, the number of seeds/capitulum, test weight and seed yield/plant. Cross 1 revealed a high heterbeltiosis with inbreeding depression for the number of branches/plant, the number of seeds/capitulum, test weight, seed yield/plant and oil content. Thus the cross 2 showed a high standard heterosis with low inbreeding depression for the number of branches/plant, the number of seeds/capitulum, seed yield/plant and oil content. Cross 2 showed a high relative heterosis with low inbreeding depression for the number of branches/plant, the number of seeds/capitulum and seed yield/plant and oil content express that these characters were determined by non-additive gene action. This could be exploited for heterosis breeding. Cross 1 and 2 showed a negative standard heterosis, relative heterosis and heterobeltiosis with inbreeding depression for days to 50 % flowering, days to maturity and hull content. The cross-2 exhibited a significant negative inbreeding depression for seed yield per plant, 100 seed weight and oil content. Hence this cross would likely to yield beneficial transgressive segregants for these traits and possibility of selecting superior recombination's for the number of branches per plant, the number of seeds per capitulum, high seed yield and high oil content in F_2 and succeeding generations. Similar results were observed by Manjare and Jambhale (1995), Kumar *et al*. (2012), Shivani *et al.* (2011), Deedawat *et al*. (2016), Patel *et al*. (2018), Satpute *et al*. (2011), Sarode *et al*. (2008), Parde *et al.* (2010), Shivani *et al.* (2011) and Patel *et al*. (2018). The main cause of heterosis as of inbreeding depression is the dominance effect and heterosis is absent when traits are influence only by additive gene action (Pirchner, 1969). If several loci are involved, the unidirectional dominance is required for realizing heterosis; otherwise heterosis may be absent even when the loci show dominance.

It was suggested that the parental genotypes GMU-2720 and GMU-3423 due to their presence in high heterotic combinations *viz.,* GMU-2720 x GMU-3423 would be further exploited in future safflower breeding programme. The cross JMU-1339 x GMU-3423 exhibited a significant negative inbreeding depression for seed yield per plant, 100 seed weight and oil content. Hence, this cross would likely to yield beneficial transgressive segregants for these traits and possibility of selecting superior recombination's for the number of branches per plant, the number of seeds per capitulum, high seed yield and high oil content in F_2 and succeeding generations.

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