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Research Note

Hybrid vigour and inbreeding depression analysis for seed yield and its related attributes in safflower (*Carthamus tinctorius* L.)

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Abstract

The present study was conducted to decipher the genetic information on heterosis and inbreeding depression for seed yield and its contributing characters in safflower (*Carthamus tinctorius* L.). The cross, JMU-1339 x NARI-6, showed a positive and significant relative heterosis, standard heterosis and heterobeltiosis for seed yield per plant while, the cross, JMU-1339 x EC-757665, exhibited positive and significant relative heterosis and heterobeltiosis along with negative standard heterosis. The cross, JMU-1339 x NARI-6, noted significant desirable heterosis for other yield contributing traits viz., the number of branches, the number of capitulum and the number of seeds per capitulum and also exhibited positive significant inbreeding depression for these characters. The cross, JMU-1339 x EC-757665, showed desirable heterosis for the number of branches, the number of seeds per capitulum and test weight with positive significant inbreeding depression for these characters. Heterosis in the cross, JMU-1339 x NARI-6, was highly significant indicating its usefulness in the direct release as a variety after thorough testing over locations. The cross, JMU-1339 x EC-757665, exhibited a significant positive heterotic value for test weight and oil content revealing its usefulness in breeding programmes to enhance this trait.

Key words: Heterosis and inbreeding depression, Safflower.

Safflower botanically known as *Carthamus tinctorius* (L.) and commonly known as “karadi” in Marathi and “kusum” in Hindi, belongs to the division Phanerogams, sub. division Angiosperm, tribe tubiflorae and family Asteraceae (Compositae). There are 36 species in this genus, out of which *Carthamus tinctorius* (L.) (2n=24) is the only cultivated species used for oil production and the rest are the wild species. It is a predominantly self-pollinated crop, however, cross pollination of 28 per cent has been reported in safflower and this is mainly through bees (Kadam and Patankar, 1942). There are nine edible oilseed crops (vegetable oil) viz., groundnut, rapeseed, mustard, sesame, sunflower, safflower, niger, linseed and soybean in India. Safflower is having prime importance in the consumer point of view as it has high nutritional

and pharmaceutical properties in seed oil and petals. The demand for edible oils is ever increasing in India and are being imported in substantial quantities due to the continuous gap between demand and supply.

The yield potential of safflower is very less and there are attempts to increase the yield by exploiting germplasm and attempting crosses for the exploitation of heterosis and widen the genetic base. The heterosis in safflower is very well reported and there are attempts to exploit the heterosis by generating hybrids. At the same time, segregating populations are also exploited to identify the genotypes having the desirable characteristics. To assess the extent of hybrid vigour in hybrids and to know the possibility of exploiting the hybrid vigour at a commercial

scale, it is essential to evaluate newly developed crosses as well as parents for seed yield and its related attributes. As safflower is a self pollinated crop, inbreeding depression was reported in the segregating populations. Hence, it is important to know the per cent of inbreeding depression before the material is being exploited at the commercial level. Inbreeding depression and heterosis together provides an estimation of gene action in particular crosses. Therefore, the present investigation was carried out to study the heterosis and inbreeding depression for the identification of promising crosses for better exploitation in a future breeding programme in safflower.

The present investigation was conducted at the experimental farm of the College of Agriculture, Latur during *rabi*, 2019-2020 (Crossing) and *rabi* 2020-2021 (evaluation). The genetic analysis of ten characters was studied in the experimental material comprised of two parents (P_1 and P_2), F_1 and F_2 generations of crosses viz., JMU-1339 x NARI-6 and JMU-1339 x EC-757665. Hand emasculatation and pollination were used for the generation of F_1 s. The crosses were evaluated in a Randomized Block Design during *rabi*, 2020-2021 and replicated twice. Each plot consisted of two rows of P_1 , P_2 , F_1 and four rows of F_2 . Each row was 3.20 meters long. The row to row and plant to plant distance was 45 cm and 20 cm, respectively. Recommended package of practices was followed to raise a good crop.

The data on ten quantitative traits were reported on five randomly selected plants in each of P_1 , P_2 and F_1 generations and 20 plants of the F_2 generation. The F_1 hybrid's performance was calculated as the heterosis over standard checks and better parent as per Fonseca and

Patterson (1968). Inbreeding depression was computed by the formula

$$[(F_1 - F_2) / F_1] \times 100$$

The analysis of variance for the experiment showed significant differences among the parents and hybrids for all the traits studied indicating greater diversity among the lines and hybrids (Table 1). The range of relative heterosis, heterobeltiosis, standard heterosis and inbreeding depression for ten traits is presented in Table 2. The standard heterosis was estimated on the check, Sharda, the best commercial variety in the region. The high values for heterotic effects also indicated that the parents used for the study were widely diverse.

Earliness in flowering, maturity and dwarf stature are the desirable traits for any crop including safflower. Hence, the cross combinations which exhibit heterosis in the negative direction are of immense value for these traits. The hybrids, JMU-1339 x NARI-6 and JMU-1339 x EC-757665 exhibited negative heterotic values for days to 50% flowering, maturity and plant height over the better parent, mid parent and standard check and also exhibited negative and significant inbreeding depression values indicating further selection for these traits may be rewarding. A similar result was observed by Shivani *et al.* (2011). The characters, the number of branches per plant, the number of capitulum per plant, the number of seeds per capitulum, test weight are yield contributing characters. The magnitude of standard heterosis for the number of branches per plant was significant and was ranged from 19.26 to 12.59 per cent for crosses, JMU-1339 x NARI-6 and JMU-1339 x EC-757665. Heterosis for better parent and mid parent also showed positive and significant heterotic values for both the

Table 1. Analysis of variance of two crosses for ten characters in safflower

Sources	d.f	DF	DM	PH	NBPP	NCPP	NSPC	TW	HC	OC	SYPP
JMU-1339 x NARI-6											
Replication	1	1.96	5.46	2.61	1.68	9.63	3.30	0.053	1.47	0.27	4.38
Treatment	5	18.52**	35.30**	136.49**	7.95*	25.036**	15.73*	0.10*	12.55**	5.86**	126.91**
Error	5	0.97	2.51	9.74	0.78	1.74	1.43	0.009	0.37	0.19	3.20
JMU-1339 x EC-757665											
Replication	1	0.52	4.08	1.11	0.96	2.61	0.013	0.00083	0.21	0.13	4.62
Treatment	5	23.87**	29.92**	70.91**	2.95*	12.73*	6.39*	0.08*	9.94*	6.97*	36.56*
Error	5	1.32	2.12	9.57	0.37	2.34	1.14	0.012	1.06	0.78	5.04

* and ** Significant at 5 and 1 per cent levels, respectively.

Where,

DF = Days to 50% flowering

NBPP = Number of branches per plant

TW = Test weight

OC = Oil content

DM = Days to maturity

NCPP = Number of capitulum per plant

SYPP = Seed yield per plant

PH = Plant height

NSPC = Number of seeds per capitulum

HC = Hull content

Table 2. Estimate of better parent heterosis, mid-parent and standard heterosis in two crosses of safflower.

Crosses	Heterosis			Inbreeding depression (%)
	Better parent (%)	Mid-parent (%)	Standard heterosis (%) (over Sharda)	
Days to 50% flowering				
JMU-1339 x NARI-6	-4.39*	-7.44**	-8.07**	-6.79**
JMU-1339 x EC-757665	-4.28*	-7.63**	-8.32**	-9.35**
Days to maturity				
JMU-1339 x NARI-6	-4.00*	-6.36**	-5.88**	-5.91**
JMU-1339 x EC-757665	-4.87*	-6.44**	-6.12**	-6.09**
Plant height				
JMU-1339 x NARI-6	-8.32	-17.63**	-5.91	-21.10**
JMU-1339 x EC-757665	-9.36	-14.65**	-6.33	-17.97**
Number of branches per plant				
JMU-1339 x NARI-6	33.05**	40.00**	19.26**	20.80**
JMU-1339 x EC-757665	16.03*	22.08**	12.59*	12.17**
Number of capitulum per plant				
JMU-1339 x NARI-6	12.95*	22.95**	7.45	16.60**
JMU-1339 x EC-757665	-2.67	5.99	-6.30	0.612
Number of seeds per capitulum				
JMU-1339 x NARI-6	15.91*	22.48**	9.30*	15.67**
JMU-1339 x EC-757665	10.50*	13.17*	-0.49	11.31**
Test weight				
JMU-1339 x NARI-6	-6.89*	-2.41	-6.90	-1.23
JMU-1339 x EC-757665	4.81	7.40*	0.00	6.89**
Hull content				
JMU-1339 x NARI-6	-6.37*	-12.93**	-0.62	-12.07**
JMU-1339 x EC-757665	-6.88	-11.17**	4.00	-11.53**
Oil content				
JMU-1339 x NARI-6	8.72**	13.33**	6.55**	6.99**
JMU-1339 x EC-757665	10.09*	14.59**	9.03**	11.02**
Seed yield per plant				
JMU-1339 x NARI-6	25.12**	48.10**	16.11**	24.85**
JMU-1339 x EC-757665	20.23*	32.04**	-6.29	18.96**

* and ** Significant at 5 and 1 per cent levels, respectively.

crosses. The trait, capitulum per plant, exhibited a negative standard heterotic value (-6.30%) in the cross, JMU-1339 x EC-757665, indicating a low number of capitulum per plant but this cross showed low inbreeding depression value indicating there is a chance for transgressive segregation in further generations. The results were in agreement with the findings of Manjare and Jambhale (1995) and Kumar *et al.* (2012) who reported a parallel relationship between heterosis and inbreeding depression.

The cross, JMU-1339 x NARI-6, showed positive and significant heterosis values over better parent (15.91%), mid parent (22.48%) and standard check (9.30%) for the number of seeds per capitulum but the cross, JMU-1339 x EC-757665, registered negative standard heterotic value. Both the crosses had high inbreeding depression values. Test weight for the cross, JMU-1339 x NARI-6, registered negative heterotic values for heterobeltiosis, relative heterosis and economic heterosis indicating small seed size and more number of seeds per capitulum. This

cross also recorded a low inbreeding depression value. The cross, JMU-1339 x EC-757665, registered the same value as the standard check for test weight. These results are in conformity with the findings of Shivani *et al.* (2010) and Ratnaparkhi *et al.* (2012).

Heterosis for oil content value ranged from 6.55 to 9.03 per cent and 13.33 to 14.57 per cent and 8.72 to 10.09 per cent for standard heterosis, mid parent heterosis, heterobeltiosis, respectively for both the crosses. Hull content exhibited negative heterotic values while oil content exhibited positive significant heterotic values *i.e.* both the traits exhibit negative correlation with each other. Inbreeding depression value for oil content was highly significant for both crosses that means there is high segregation for this trait and further selection is not useful. Kumar *et al.* (2012) recorded a similar result for this trait. Developing high yielding hybrids and varieties is the main objective in safflower and improvement in yield can be achieved by selecting yield contributing characters. The cross, JMU-1339 x NARI-6, registered positive significant standard heterosis value (16.11%), positive significant heterobeltiosis (25.12%) and mid parent heterosis value (48.10%) for seed yield per plant. A negative standard heterotic value for seed yield per plant was recorded for cross JMU-1339 x EC-757665 (-6.29%) and positive significant heterosis values were noted over mid parent (32.04%) and better parent (20.23%). Both the crosses showed a high inbreeding depression value for this trait. Similar results were reported by Shivani *et al.* (2010) and Patel and Shrivastava (2016) for seed yield per plant.

The cross, JMU-1339 x NARI-6 for characters, days to 50% flowering, days to maturity, plant height and hull content exhibited heterosis over better parent JMU-1339 and for the number of branches per plant, the number of capitulum per plant, the number of seeds per capitulum, test weight, oil content and seed yield per plant exhibited heterosis over better parent NARI-6. Similarly for the cross, JMU-1339 x EC-757665 for characters, days to 50% flowering, days to maturity, plant height and hull content exhibited heterosis over better parent JMU-1339 and for the number of branches per plant, the number of capitulum per plant, the number of seeds per capitulum, test weight, oil content and seed yield per plant exhibited heterosis over better parent EC-757665.

High heterosis and high inbreeding depression value were observed for the number of branches per plant, the number of seeds per capitulum and seed yield in the cross, JMU-1339 x NARI-6 exhibiting the presence of non-additive gene action for those traits. High heterosis and low inbreeding depression value was observed for oil content in both the crosses and for the number of branches per plant in the cross, JMU-1339 x EC-757665 exhibiting the presence of additive gene action for those traits and can be exploited in further generations.

The cross, JMU-1339 x NARI-6 for best heterotic values in traits, *viz.*, the number of branches per plant, the number of seed per capitulum, oil content and seed yield can be exploited in further generations or in future breeding programmes. Also, the cross, JMU-1339 x EC-757665, exhibited a significant positive heterotic value for the number of branches, test weight and oil content, hence this cross can be exploited for these traits in the future safflower breeding programme. Both the crosses exhibited negative standard heterotic values for maturity and plant height, which was desirable, these characters can be utilized in future breeding programmes. Heterosis and inbreeding depression together provide the nature of gene action, traits showing high heterosis and low inbreeding depression values can be exploited in further generations.

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