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Identification of potential hybrids for heterosis breeding in sesame (*Sesamum indicum* L.)

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ABSTRACT

The extent of heterosis for eleven traits, including seed yield per plant, was investigated in sesame. During summer 2019, 21 F_1 crosses from 7 parents (GT 03, SKT 1501, AT 413, AT 383, AT 338, AT 307 and AT 345) were developed by using a diallel mating (7 x 7) design that excluded reciprocals. In Kharif 2019, twenty-nine entries (genotypes) which including a check (GT-04), seven parents, and their 21 F_1 hybrids were evaluated in randomized block design (RBD) with three replication at the 'Agronomy Instructional Farm, S. D. Agricultural University, Sardarkrushinagar, Gujarat'. The highly significant and positive standard heterosis with high per se performance for seed yield per plant and some of its component traits were recorded in the crosses viz GT 03 x SKT 1501, GT 03 x AT 307, GT 03 x AT 345, SKT 1501 x AT 307, AT 413 x AT 307, and AT 307 x AT 345. Five hybrids showed highly significant positive heterobeltiosis for seed yield per plant, while six hybrids showed highly significant positive standard heterosis for seed yield per plant. In Sesame, the current research shows that there is a lot of potential for isolating pure lines from heterotic F_1s progenies as well as commercialising heterosis.

Keywords: Sesame, heterosis, standard heterosis, heterobeltiosis and diallel mating

INTRODUCTION

Sesame (*Sesamum indicum* L., Pedaliaceae) is one of the oldest oilseed crops, grown in tropical and sub-tropical countries. It's a self-pollinated annual diploid herb that blooms every year Aye *et al.* (2018). Because it contains significant levels of unsaturated fatty acids and antioxidants such as sesamol, sesamin, sesamolin, and sesaminol, sesame oil is regarded the queen of high-quality vegetable oils for human consumption. Sesame seeds contain 40-52 % oil, 20-27 % protein, 6-7 % moisture, 16 % carbohydrate, and 6-8 % crude fiber. It is highly drought tolerant but photo and thermo-sensitive, high ability to adapt and produce seed well under fairly high temperature. However, moisture levels before planting and flowering have great impact on the seed yield (Chaudhari *et al.* 2017). One of the approaches used in plant breeding to generate cultivars with high yielding potential is to take advantage of hybrid vigour (Sapara *et al.*2019). It has been observed that the yields of F_1 hybrids are significantly higher than those of the better parents in some cases. The degree of genetic divergence between the parents is connected to the amount of heterosis in sesame, as it is in many other crops. Significant negative relative heterosis, heterobeltiosis, and standard heterosis for days to 50 % flowering in three crosses, as well as significant positive heterosis for the number of primary branches per plant (Nayak *et al.* 2018). The present investigation was, therefore, undertaken to identify potential hybrids for heterosis breeding in sesame.

MATERIAL AND METHODS

The seven parental lines *viz;* GT 03, SKT 1501, AT 413, AT 383, AT 338, AT 307 and AT 345 included in the present investigation were sown during *summer* 2019 at S. D. A. U., Sardarkrushinagar, (Gujarat) by adopting a spacing of 45 cm between rows and 15 cm between plants within a row. Normal agronomic practices as recommended for sesamum along with plant protection measures and irrigation were followed as and when required. To get 21 F_1s, crosses were made between parental lines using half diallel method. At the same time, the parents were selfed to get pure seeds of parents for experiment. Hybridization was carried out by hand emasculation followed by manual hand pollination. The hybridization process was continued for about 35 days to obtain sufficient seed in each combination. The crossed seed of each combination were collected separately when the individual capsules attained maturity.

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During *Kharif* 2019, the experimental material, which included 29 entries (including check GT 04) involving seven parents and their 21 F_1 hybrids, was sown in a three-replication randomized block design. Each replication had one row with 29 entries in it. The row was 4 meters long. Inter and intra row spacing of 45 cm and 15 cm were used, respectively. Observations were recorded on randomly selected five tagged plants for seed yield per plant and its attributes *viz.* plant height, number of primary branches per plant, number of capsules per plant, number of seeds per capsule, capsule length, 1000 seed weight, seed yield per plant, harvest index, oil content and the character's like days to flowering and days to maturity. The method proposed by Panse and Sukhatme was used to perform analysis of variance for all characteristics. As indicated by Fonseca and Patterson (1968) and Meredith and Bridge (1972), heterobeltiosis and standard heterosis were calculated as a deviation of F_1 value from the better-parent and standard parent, respectively.

RESULT AND DISCUSSION

The ANOVA for the mean sum of squares for genotype showed significant differences for almost all characters studied indicating the presence of sufficient variability among genotypes. The variances due to parents were significant for all the traits except plant height, number of primary branches per plant, number of seeds per capsule, capsule length and harvest index. While the hybrids showed significant differences for all eleven characters revealing the presence of sufficient genetic variability among hybrids for all of the characters studied. Parents *Vs* hybrids also showed significant difference for number of capsules per plant, capsule length and seed yield per plant.

In terms of seed yield per plant, heterobeltiosis was observed for several cross combinations. The results exhibited that out of 21 hybrids, five hybrids (GT 03 x SKT 1501, GT 03 x AT 307, GT 03 x AT 345, SKT 1501 x AT 307 and AT 413 x AT 307) showed significant and positive heterosis over better parent. Standard heterosis in significant desired direction for seed yield per plant was exhibited by six hybrids (GT 03 x SKT 1501, GT 03 x AT 307, GT 03 x AT 345, SKT 1501 x AT 307, AT 413 x AT 307, AT 307 x AT 345) with range of -38.90 % (SKT 1501 x AT 413) to 42.18 % (SKT 1501 x AT 307) (Table 2). The low to moderate range of heterobeltiosis and standard heterosis for seed yield per plant also reported in sesame by Dela and Sharma (2019), Sapara *et al.* (2019) and Daba *et al.* (2019). The lower values of heterosis for days to flowering are desirable. Significant negative heterosis over better parent was observed in eight hybrids (GT 03 x SKT 1501, GT 03 x AT 383, GT 03 x AT 338, GT 03 x AT 307, SKT 1501 x AT 413, AT 413 x AT 307, AT 383 x AT 307, AT 307 x AT 345) out of 21 hybrids. Whereas, only one hybrid (GT 03 x AT 383) observed significant negative heterosis over commercial check out of 21 hybrids. Similar results were also observed by Nayak *et al.* (2018), Chaudhari *et al.* (2017) and Beniwal *et al.* (2018).

Significant negative heterosis over better parent for days to maturity was observed in four hybrids GT 03 x SKT 1501 (-4.15 %), SKT 1501 x AT 413 (-3.46 %), AT 413 x AT 338 (-3.79 %), AT 383 x AT 307 (-3.85 %) out of 21 hybrids (Table 1). The result was in confirmation with the findings by Sundari and Kamala (2012) and Aye *et al.* (2018). For plant height only one hybrid GT 03 x SKT 1501(-12.24 %) over better parent and one hybrid GT 03 x AT 307 (-10.46 %) over standard heterosis exhibited standard negative and significant heterosis in plant height. The result were in agreement with the findings of Imran *et al* (2017), Chaudhari *et al.* (2017) and Nayak *et al.* (2017). The four crosses GT 03 x SKT 1501 (16.32 %), GT 03 x AT 307 (18.42 %), SKT 1501 x AT 307 (16.84 %), AT 307 x AT 345 (16.84 %) exhibited the significant positive heterosis over standard parent for number of primary branches per plant. Nayak *et al.* (2017) reported similar results in sesame.

Out of 21 hybrids, only one hybrid AT 383 x AT 345 (28.51 %) are exhibited significant and positive heterosis over better parent and, six hybrids GT 03 x SKT 1501 (22.45 %), GT 03 x AT 307 (18.57 %), GT 03 x AT 345 (15.58 %), SKT 1501 x AT 307 (16.87 %), AT 413 x AT 307 (18.52 %), AT 307 x AT 345 (18.36 %) exhibited significant positive heterosis over the standard check for number of capsules per plant (Table 1).The finding of Rani *et al.* (2015) and Patel *et al.* (2016) confirmed this work. For number of seeds per capsule, two of hybrids SKT1501 x AT 383 (9.94 %) and AT 413 x A T 345 (9.02 %)

Table 1: Magnitude of heterosis in percentage in F_1 hybrids over better parent (BP) and standard check (SC) GT 04 for days to flowering, days to maturity, plant height, primary branches/plant, capsules/plant and seed/capsule

Sr. NO.	Name of crosses	Days to flowering		Days to maturity		Plant height (cm)		Primary branches/plant		Capsules/plant		Seeds/capsule	
		BP (%)	SC (%)	BP (%)	SC (%)	BP (%)	SC (%)	BP (%)	SC (%)	BP (%)	SC (%)	BP (%)	SC (%)
1	GT 03 x SKT 1501	-8.22*	-2.19	-4.15*	-0.36	-12.24*	-8.31	9.41	16.32*	11.99	22.45**	1.25	-2.17
2	GT 03 x AT 413	-4.44	-5.82	-2.14	-1.44	-4.88	-4.23	-1.82	4.39	1.08	10.52	3.43	5.71
3	GT 03 x AT 383	-8.96*	-10.95**	-2.54	-3.24	5.40	7.22	-17.08*	-11.84	-24.89**	-17.78*	0.15	2.11
4	GT 03 x AT 338	-10.14*	-2.91	-2.41	1.80	10.40*	10.14*	-1.49	4.74	-18.70**	-11.10	-0.80	-3.46
5	GT 03 x AT 307	-15.13**	-5.82	-2.80	0.00	-9.53	-10.46*	8.87	18.42*	8.44	18.57*	-12.53**	-15.48**
6	GT 03 x AT 345	0.77	-4.38	-0.73	-1.8	-6.56	-1.98	6.85	13.60	5.71	15.58*	0.96	0.58
7	SKT 1501 x AT 413	-10.96**	-5.10	-3.46*	0.36	7.33	12.14*	-21.86**	-18.16*	-25.04**	-35.44**	3.81	6.11
8	SKT 1501 x AT 383	-4.11	2.19	0.00	3.96*	-0.44	4.02	-2.92	-3.68	-5.78	-21.32**	7.82	9.94*
9	SKT 1501 x AT 338	-2.70	5.12	0.00	4.32**	3.32	7.95	1.86	1.05	6.17	-11.68	-15.40**	-17.68**
10	SKT 1501 x AT 307	-4.61	5.84	-1.38	2.52	-7.86	-3.73	7.42	16.84*	8.67	16.87*	-16.78**	-19.66**
11	SKT 1501 x AT 345	-3.42	2.93	-1.04	2.88	6.41	11.71*	-1.46	0.88	-2.18	-14.08	5.77	5.37
12	AT 413 x AT 383	7.41	5.84	1.43	2.16	7.54	9.37	-4.02	0.53	9.42	-5.76	-9.35*	-7.35
13	AT 413 x AT 338	-3.38	4.38	-3.79*	0.36	1.03	1.71	-8.04	-3.68	-10.71	-23.10**	4.80	7.12
14	AT 413 x AT 307	-13.82**	-4.38	-2.80	0.00	0.57	1.25	4.52	13.68	10.20	18.52*	-0.30	1.90
15	AT 413 x AT 345	2.96	1.46	0.00	0.72	7.38	12.72**	-5.28	-0.79	-24.97**	-34.10**	6.66	9.02*
16	AT 383 x AT 338	-1.35	6.57	-2.07	2..16	-7.52	-5.93	-3.77	-6.05	6.27	-18.65*	2.35	4.36
17	AT 383 x AT 307	-11.84**	-2.19	-3.85*	-1.08	-0.90	0.80	-5.65	2.63	-11.68	-5.01	-3.70	-1.82
18	AT 383 x AT 345	-0.75	-2.91	-0.36	-1.08	-8.80	-4.27	2.31	4.74	28.51**	12.88	-15.31**	-13.65**
19	AT 338 x AT 307	0.00	10.95**	-1.03	3.24	0.72	0.50	-11.69	-3.95	-24.66**	-18.97**	10.78*	7.80
20	AT 338 x AT 345	-6.08	1.46	-3.45	0.72	3.34	8.48	-12.60	-10.53	-25.42**	-34.49**	7.25	6.84
21	AT 307 x AT 345	-11.18**	-1.44	-2.80	0.00	-8.08	-3.50	7.42	16.84*	10.05	18.36*	3.35	2.96
S.Ed ±		1.90	1.90	1.52	1.52	6.00	6.00	0.30	0.30	4.54	4.54	3.14	3.14

*BP = Better Parent; SC = Standard Check *P**≤ 0.05, ** P ≤ 0.01***

Table 2: Magnitude of heterosis in percentage in F_1 hybrids over better parent (BP) and standard check (SC) GT 04 for capsule length, 1000 seed weight, seed yield/plant, harvest index and oil content

Sr. NO.	Name of crosses	Capsule length (cm)		1000 seed weight (g)		Seed yield/plant (g)		Harvest index (%)		Oil content (%)	
		BP (%)	SC (%)	BP (%)	SC (%)	BP (%)	SC (%)	BP (%)	SC (%)	BP (%)	SC (%)
1	GT 03 x SKT 1501	10.65	10.29	-2.42	15.36**	35.23**	28.83**	17.66	33.73**	-12.75	-1.51
2	GT 03 x AT 413	8.51	10.72	-23.79**	-9.90	11.69	6.41	-1.88	11.51	8.80	12.45*
3	GT 03 x AT 383	-4.46	3.22	-19.60**	-4.95	-35.55**	-38.60**	-11.49	0.59	5.12	8.77
4	GT 03 x AT 338	-8.06	-8.36	-8.15	8.59	-12.57	-16.70*	-5.84	7.01	2.46	6.02
5	GT 03 x AT 307	-4.70	-6.75	-0.66	17.45**	19.23**	33.87**	8.01	26.92*	-9.20	-3.73
6	GT 03 x AT 345	15.69*	12.22	-23.35**	-9.38	21.38**	21.84**	18.14	34.27**	-11.94*	4.13
7	SKT 1501 x AT 413	3.68	5.79	-8.62	-8.85	-31.60**	-38.90**	-11.85	-5.63	-3.77	8.62
8	SKT 1501 x AT 383	8.53	17.26**	14.88**	14.58**	4.90	-11.75	-3.28	7.77	-4.94	7.31
9	SKT 1501 x AT 338	-0.43	-0.75	3.08	13.28*	13.51	-4.50	-17.30	-11.47	-15.01**	-4.06
10	SKT 1501 x AT 307	-12.90*	-13.18*	2.04	17.19**	26.63**	42.18**	7.47	26.29*	-8.42	3.38
11	SKT 1501 x AT 345	12.47*	12.11	16.97**	16.67**	12.61	13.04	-15.93	-5.54	1.28	19.76**
12	AT 413 x AT 383	-15.77**	-9.00	18.33**	14.32**	-11.27	-20.75*	18.62	32.17**	-2.58	-0.15
13	AT 413 x AT 338	11.03	13.29*	-9.72	-0.78	-0.43	-11.06	-1.67	3.57	8.84	7.25
14	AT 413 x AT 307	4.41	6.54	-20.86**	-9.11	21.88**	36.84**	17.23	37.76**	-4.66	1.11
15	AT 413 x AT 345	5.25	7.40	9.56	2.43	-24.32**	-24.03**	-4.15	7.69	-4.03	13.49*
16	AT 383 x AT 338	3.57	11.90	-13.27**	-4.69	9.83	-11.37	-14.59	-4.83	6.97	9.64
17	AT 383 x AT 307	2.18	10.40	-11.11*	2.08	-34.92**	-26.93**	-16.08	-1.39	-11.34*	-5.97
18	AT 383 x AT 345	4.17	12.54	23.72**	19.53**	12.16	12.59	15.14	29.36*	-10.79*	5.50
19	AT 338 x AT 307	3.55	3.22	-19.50**	-7.55	-35.80**	-27.92**	-24.70*	-11.51	2.73	8.95
20	AT 338 x AT 345	9.68	9.32	-17.77**	-9.64	-28.04**	-27.77**	-5.64	6.01	-13.41**	2.39
21	AT 307 x AT 345	13.80*	11.36	2.27	17.45**	10.94	24.50**	11.08	30.53**	-11.77*	4.34
S.Ed ±		0.19	0.19	0.20	0.20	1.04	1.04	2.78	2.78	2.18	2.18

*BP = Better Parent; SC = Standard Check *P≤ 0.05, ** P ≤ 0.01* showed significant positive heterosis over standard check and only one hybrid AT 338 x AT 307 (10.78 %) showed significant and positive heterosis over better parent. Three hybrids GT 03 x AT 345 (15.69 %), SKT 1501 x AT 345 (12.47 %), and AT 307 x AT 345 (13.80 %) over better parent and two hybrids AT 413 x AT 338 (13.29 %) and SKT1501 x AT 383 (17.26 %) over standard parent showed significant and positive heterosis for capsule length. The results were in agreement with the finding of Vavdiya *et al.* (2013) and Chaudhari *et al.* (2017).

Table 3: Range of heterobeltiosis and standard heterosis, mean value of heterosis, top three ranking cross and number of crosses with specific heterotic effects for various traits in sesame

Characters	Range of heterosis (%)		No. of positive significant		No. of negative significant		Mean value	Best Performing Hybrids
	BP	SH	BP	SH	BP	SH		
Days to flowering	-15.13 to 7.41	-10.95 to 10. 95	0	1	8	1	45.83	GT 03 x AT 383 GT 03 x AT 413 GT 03 x AT 307
Days to maturity	-4.15 to 1.43	-3.24 to 4.32	0	2	4	0	93.44	GT 03 x AT 383 GT 03 x AT 345 GT 03 x AT 413
Plant height (cm)	-12.14 to 10.40	-10.46 to 12.72	1	4	1	1	122.95	GT 03 x AT 307 GT 03 x SKT 1501 AT 383 x AT 338
Number of primary branches per plant	-21.86 to 9.41	-18.16 to 18.42	0	4	2	1	3.90	GT 03 x AT 307 SKT 1501 x AT 307 AT 307 x AT 345
Number of capsules per plant	-25.42 to 28.51	-35.44 to 22.45	1	6	6	8	57.76	GT 03 x SKT 1501 GT 03 x AT 307 AT 413 x AT 307
Number of seeds per capsule	-16.78 to 10.78	-19.66 to 9.94	1	2	5	4	70.43	SKT 1501 x AT 383 AT 413 x AT 345 AT 413 x AT 338
Capsule length (cm)	-15.77 to 15.69	-13.18 to 17.26	3	2	2	1	3.24	AT 383 - -
1000 seed weight (g)	-23.79 to 23.72	-9.90 to 19.53	4	9	8	0	4.00	SKT 1501 AT 307 -
Seed yield per plant (g)	-35.80 to 35.23	-38.90 to 42.18	5	6	6	8	12.63	AT 307 GT 03 AT 345
Harvest index (%)	-24.70 to 18.62	-11.51 to 37.76	0	8	1	0	26.57	AT 307 GT 03 -
Oil content (%)	-15.01 to 8.84	-5.97 to 19.76	0	3	7	0	41.71	AT 345

*BP = Better Parent; SC = Standard Check *P≤ 0.05, ** P ≤ 0.01*

Heterosis for 1000 seed weight over better parent was found in four hybrids SKT 1501 x AT 383 (14.88 %), SKT 1501 x AT 345 (16.97 %), AT 413 x AT 383 (18.33 %) and AT 383 x AT 345 (23.72 %) and nine hybrids (GT 03 x SKT 1501, GT 03 x AT 307, SKT 1501 x AT 383, SKT 1501 x AT 338, SKT 1501 x AT 307, SKT 1501 x AT 345, AT 413 x AT 383, AT 383 x AT 345 and AT 307 x AT 345) showed significant and positive heterosis over standard parent. For harvest index (%), eight hybrids GT 03 x SKT 1501 (33.73 %), GT 03 x AT 345 (34.27 %), GT 03 x AT 307 (26.92 %), SKT 1501 x AT 307 (26.92 %), AT 413 x AT 383 (32.17 %), AT 413 x AT 307 (37.76 %), AT 383 x AT 345 (29.36 %) and AT 307 x AT 345 (30.53 %) show heterosis over standard parent. Out of 21 hybrids, three hybrids GT 03 x AT 413 (12.45

Table 4: Superior heterotic crosses and their *per se* performance for seed yield per plant and related traits in sesame

Sr. No.	Hybrids	Heterosis for seed yield per plant over		Significant standard heterosis/ heterobeltiosis for other traits in desirable direction
		Standard parent	Better parent	
1	GT 03 x SKT 1501	28.83**	35.23**	DF, DM, NPB, PH, NCPP,SW, HI
2	GT 03 x AT 307	33.87**	19.23**	DF, NPB, PH, NCPP, SW, HI
3	GT 03 x AT 345	21.84**	21.38**	NCPP, CL, HI
4	SKT 1501 x AT 307	42.18**	26.63**	NPB, NCPP, HI, SW
5	AT 413 x AT 307	36.84**	21.88**	DF, NCPP, HI
6	AT 307 x AT 345	24.50**	10.94	DF, NPB, NCPP,SW, CL, HI

Where : DF; *Days to flowering,* ***DM;*** *Days to maturity,* ***HI;*** *Harvest index,* ***PH;*** *Plant height,* ***NCPP;*** *Number of capsules per plant,* ***SW;*** *1000 seed weight,* ***NPB;*** *Number of primary branches per plant and* ***CL;*** *Capsule length*

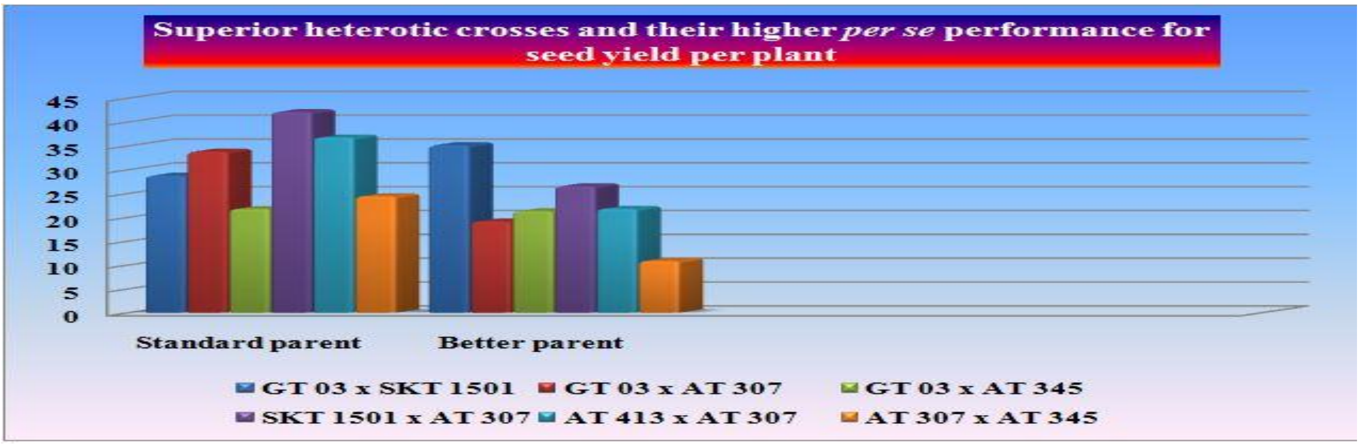

Fig 1: Comparison between hybrids that show superior hetrotic performance for Heterobeltiosis and standard herosis

%), SKT 1501 x AT 345 (19.76 %) and AT 413 x AT 345 (13.49 %) showed significant positive heterosis over standard parent. Similar results were reposted by Pawar and Monpara (2016) in sesame.

According to the results, significant heterobeltiosis and standard heterosis observed for seed yield and other associated characters suggested the presence of significant genetic diversity among the parents. On the basis of *per se* performance and heterotic response involved in the expression of yield and its attributes, the six crosses *viz.,* GT 03 x SKT 1501, GT 03 x AT 307, GT 03 x AT 345, SKT 1501 x AT 307, AT 413 x AT 307and AT 307 x AT 345 appeared to be most superior. Biparental mating or recurrent selection breeding approaches are being used in these crosses to obtain suitable segregants for the production of further superior genotypes for seed yield and its component characteristic .

REFERENCES

Aye, M.; Win, S. and Hom, N.H. (2018) Combining ability and heterosis studies in sesame genotypes. *International Journal of Advanced Research* **6**(2): 1220-1229.

Beniwal, B.; Sastry, E.V.D. and Solanki, Z.S. (2018) Combining ability and heterosis studies in sesame (*Sesamum indicum* L.). *International Journal of Genetics* **10**: 415-419.

Chaudhari, M.H.; Patel, S.R; Chaudhari, V. B. and Nayak, A.J. (2017) Studies the magnitude of heterosis for seed yield and its components in sesame. *International Journal of Development Research* **7**(8): 14282-14288.

Daba, C.; Ayana, A.; Wakjira, A. and Zeleke, H. (2019) Heterosis in sesame hybrids of diverse parental lines for agromorphological characters in ethiopia. *East African Journal of Sciences* **13**(1): 39- 50.

Dela, G. J. and Sharma, L. K. (2019) Heterosis for seed yield and its components in sesame (*Sesamum indicum* L.). *Journal of Pharmacognosy and Phytochemistry* **8**(4): 1345-1351.

Fonseca, S. and F.L. Patterson. (1968) Hybrid vigour in seven parental diallel cross in common winter wheat (*Triticumaestivum*L.). *Crop Science* **8**(1): 85-88.

Imran, M.; Dash, M.; Das, T.R.; Kabi, M.; Baisakh, B. and Lenka, D. (2017) Studies on heterosis for yield and yield attributes in sesame (sesamum *indicum L.). e-Planet* **15**(2): 107- 116.

Meredith, W.R. and Bridge, R.R. (1972) Heterosis and gene action in cotton (*G. hirsutum* L.). *Crop Science* **12**(3): 304 - 310.

Nayak, A.J.; Patel, S.R. and Shrivastva, A. (2017) Heterosis studies for yield and its components traits in sesame (*Sesamum indicum* L.). *AGRES – An International e-Journal* **6**(1): 38-48.

Patel, R.M.; Chauhan, R.M. and Patel, J.A. (2016) Heterosis for yield and yield components in sesame (Sesamum *indicum L.*) *Electronic Journal of Plant Breeding* **7**(4): 1151- 1154.

Pawar, A.K. and Monpara, B.A. (2016) Studies on gene effects for oil and some yield attributing traits in sesame. *Journal of Global Agriculture and Ecology* **4**(4): 215-220.

Rani, S.T.; Babu, K.T.; Rao, M.P.; Thippeswamy, S.; Raddy, K. and Soujanya, G. (2015) Heterosis study in sesame (*Sesamum indicum L.)*. *International Journal of Plant, Animal and Environmental Sciences* **5** (7): 177-183.

Sapara, G.K.; Patel, J.B. and Barad, H.R. (2019) Heterosis for yield and its components in sesame [*Sesamum indicum* L.] over environments. *Electronic Journal of Plant Breeding* **10**(1): 207 – 213.

Sundari, P.M. and Kamala, T. (2012) Heterosis in *Sesamum indicum* L. *Asian Journal of Agricultural Sciences* **4**(4): 287-290.

Vavdiya, P.A.; Dobariya, K.L.; Babariya, C.A. and Sapovadiya, M.V. (2013) Heterosis for seed yield and its components in sesame (*Sesamum indicum* L.). *Electronic Journal of Plant Breeding* **4**(3): 1246-1250.