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Identification of Potential Heterotic Crosses for Development of Hybrid in Sesame

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ABSTRACT

Heterosis breeding is a potent genetic tool for exploitation of non-additive gene action. Knowledge on the extent of heterosis immensely help in identification of potential crosses for either hybrid development or for availing scope for selection of superior segregants. Twenty-eight crosses were evaluated for heterosis developed using diallel mating design from eight parent for fourteen biometric traits. Superior crosses were identified for each fourteen traits studied. For the character, days to 50% flowering, Rama with AT-382 exhibited highest mid-parent heterosis (-22.39 %) and better parent heterosis (-31.58 %) and standard heterosis (-29.73 %) in negative direction. Similarly, AT-382 with VRI-1 showed highest mid parent heterosis (-11.80 %) and better parent heterosis (-20.22 %) in negative direction for days to maturity. For seed yield per plant, AT-382 with Krishna produced highest heterosis over mid-parent (92.46%), highest heterosis over better parent (89.32%) and also highest heterosis over check variety (33.27 %). Krishna with Uma showed highest heterosis (58.21%) over mid-parent, over better parent (51.43%) and over standard check (47.22%) for oil content. Keeping in importance of the trait and percentage of heterosis, we identified three best cross; AT-382 with VRI-1 for early maturity, AT-382 × Krishna topped among all cross for seed yield per plant and Krishna × Uma identified as the best cross for oil percentage.

Keywords: Heterosis, Average heterosis, Heterobeltiosis, Standard heterosis, Sesame

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INTRODUCTION

Sesame is one of the ancient oil yielding crops known to human being. It is generally known as gingelly, benniseed, simsim, til or tal. It deserves to be the queen of oilseed crops owing to its excellent nutritional and health benefits. Sesame oil is highly resistant to oxidative deterioration due to presence of a variety of lignans (sesamin, sesamolin, sesamol and γ-tocopherol). It is highly drought tolerant crop and grows well in most kinds of soils and is well suited to different crop rotations. However, its productivity continues to be very low particularly due to its cultivation in rainfed areas, use of shattering varieties, lack of hybrid varieties and sensitivity to biotic and abiotic stresses (Lakhanpaul et al., 2012). The progress towards augmentation of productivity is indeed slow. In this context, development of widely adaptable hybrids across the country can be a suitable solution (Susmith et al., 2023). Certain cross combinations (F1 hybrids) are often selected for cultivation owing to their heterotic performance over parent(s) (Ranganatha et al., 2012). Breeders can use different hybridization techniques (Ranganatha et al., 2012) and the resulting heterotic effects can be harnessed as a breeding tool to select the promising hybrids in favorable directions for early maturity, yield and yield attributing traits (Lekshmi et al., 2023; Veldandi et al., 2021). Therefore, the present investigation was undertaken to identify promising heterotic hybrids for yield and associated traits including oil content in sesame using a 8x8 half-diallel mating design.

MATERIALS AND METHODS

The research work presented was carried out in the experimental area of the department of Plant Breeding and Genetics, College of Agriculture, Bhubaneswar, OUAT. Twenty-eight crosses were developed using eight parents in by fevicol method of pollination. Twenty-eight crosses with eight parents were planted in field Randomized Block Design (RBD). Crosses were raised following recommended package of practices for sesame. Fourteen characters; days to 50% flowering, days to maturity, plant height, plant height upto1st branching, plant height up to 1st capsule bearing node, branches per plant, internode length, capsules per plant, seeds per capsule, capsule length, capsule width, 100-seed weight, yield per plant, and oil percentage were studied for heterosis. Data on days to 50% flowering and days to maturity were recorded on plot basis whereas for rest twelve characters, observation on five competitive plants per replication were recorded.

The data were subjected to statistical analysis of variance technique given by Steel et al. (1997) to determine significant

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differences among genotypes for traits. Significantly different parents were further analyzed for heterosis following the formula given by Panse and Sukhatme (1962). Three types of heterosis were estimated as percentage of F1s over mid parent (MP), better parent (BP) and standard check (SC) as per formula given by Turner (1953).

RESULTS AND DISCUSSION

Heterosis breeding is a potent genetic tool for exploitation of the non-additive gene action. It is affected by divergence, genetic base, adaptability and mode of pollinationof parents. Heterosis increases fitness and vigor of F1s over its parents for a trait, which decreases with advancement of generations due to segregation and recombination. The estimates of heterosis may be both in positive and negative direction. Only a few heterotic combinations may be identified after evaluation of huge number of cross combinations and such hybrids may be proposed for commercial cultivation. In Sesame, commercial exploitation of heterosis seems to be a reality owing to identification of male sterile lines and presence of a considerable amount of natural cross-pollination. In the present investigation, twenty-eight crosses along with eight parents were analyzed for analysis of variance (ANOVA) that reveals high significant difference among the parents (except for branches per plant), hybrids (except plant height) as well as parents -vs- hybrids for almost all the traits under study (Table1). Significance of 'Parents vs. Hybrids' indicated role of parent(s) in specific cross combinations for overall heterosis for all the traits under study. Therefore, the present set of crosses were subjected to further analysis of heterosis.

The range of the F1 values was distinctly beyond the parental range in the favorable direction for ten out of fourteen characters viz., days to 50% flowering, days to maturity, plant height, branches per plant, internode length, capsules per plant, seeds per capsule, capsule length, capsule width and yield per plant (Table 2). This is indication of the role of non-additive gene action as reported by Bangar et al. (2010). Prajapati et al. (2010), Praveenkumar et al. (2012a), Abatchoua et al. (2014), Azeez and Morakiny (2014), Abdel- and Chauhan (2019a) for natural pollination, mulching, and induced pollination techniques.

Table 1: Analysis of variance of parents and hybrids (F1) for fourteen characters

Character	Genotype (35)	Parent (7)	Hybrid (27)	Parent vs Hybrid (1)	Error (70)	CV (%)
DF	33.75**	38.52**	26.11**	206.67**	3.39	5.93
DM	150.94**	107.79**	167.95**	20.50**	2.72	1.99
PH	888.27**	909.02**	179.40	19882.3**	81.70	6.64
PHB	134.44**	146.24**	110.33**	702.84**	44.10	23.53
PHC	243.18**	238.40**	82.89**	4604.49**	31.69	9.32
B/P	3.32**	1.19	2.63**	36.83**	1.033	23.49
IL	5.65**	6.59*	5.02*	15.80***	2.90	29.53
C/P	1409.84**	665.12**	1293.42**	9766.07**	92.97	11.37
S/C	126.46**	58.82*	95.64**	1432.039	28.12	7.54
CL	0.126**	0.165**	0.081**	1.060**	0.016	4.91
CW	0.015**	0.015**	0.014**	0.025**	0.003	7.94
HSW	0.002**	0.003**	0.001**	0.012**	0.001	5.20
Y/P	28.96**	16.63**	23.45**	264.035**	2.85	13.14
OP	190.98**	136.67**	211.26**	23.43**	3.008	4.78

(*and**indicate significance at 5% and 1% levels of probability respectively, Figure in parentheses indicate degrees of freedom for corresponding sources of variation. DF: Days to 50% flowering, DM: Days to maturity, PH: Plant height, PHB: Plant height upto1st branching, PHC: Plant height up to 1stcapsule bearing node, B/P: Branches per plant, IL: Internode length, C/P: Capsules per plant, S/C: Seeds per capsule, CL: Capsule length, CW: Capsule width, HSW: 100-seedweight, Y/P: Yield per plant, OP: Oil percentage).

All the traits except for days to maturity and 100-seed weight. In contrast, importance of both additive and non-additive gene action for various traits were reported by Banerjee and Kole (2010), Parameshwarappa and Salimath (2010), Mandal et al. (2010), Balla et al. (2017), Sumathi and Muralidharan (2014), Hassan and Sedeck (2015), Anyanga et al. (2016), Tripathy et al. (2016), Suganthi et al. (2018) and Abdel-Rhman et al. (2019). Such contradictory findings with present research may be attributed to genetic difference in materials handled and the presence of interaction between genotype and environment. However, report on the mode of gene action for plant height up to 1st branching, plant height up to 1st capsule bearing node and internode length is indeed scanty.

Table 2: Over-all mean performance of 8 parents and 28 crosses for fourteen characters in F1 generation

Characters	Parent		Hybrids		F1-P	% increase over parental mean
	Mean	Range	Mean	Range		
DF	33.63	29.00-38.00	31.03	26.00-36.67	-2.6	-7.73
DM	83.75	72.00-92.00	82.94	71.00-100.00	-0.81	-0.967
PH	110.70	85.00-134.00	136.48	129.77-162.50	25.78	23.29
PHB	23.45	10.24-32.33	28.23	18.17-38.60	4.78	20.39
PHC	48.20	34.57-60.43	63.92	50.52-72.83	15.72	32.61
B/P	3.23	2.30-4.20	4.64	3.27-6.88	1.41	43.65
IL	6.48	3.60-8.37	5.56	3.57-7.40	-0.92	-14.19
C/P	67.03	52.00-80.00	89.90	63.11-133.60	22.87	34.12
S/C	63.53	58.65-67.20	72.29	64.00-82.67	8.76	13.79
CL	2.40	2.10-2.70	2.63	2.33-2.90	0.23	9.58
CW	0.64	0.52-0.70	0.67	0.56-0.82	0.03	4.68
HSW	0.289	0.234-0.320	0.264	0.228-0.295	-0.025	-8.66
Y/P	9.92	7.34-14.86	13.68	8.54-15.12	3.76	37.90
OP	37.13	31.00-50.00	36.00	25.17-54.00	-1.13	-3.044

Furthermore, if a specific cross shows high heterosis for economic character, the cross can be utilized as commercial hybrid provided the pollinating system of the crop permits commercial seed production. High levels of heterosis have been reported for certain hybrid combinations in sesame from various countries. Estimation of average heterosis, hetero beltiosis and standard heterosis is presented in Table 3.

For the character days to 50% flowering, AT-382 with Rama exhibited highest mid-parent heterosis (-22.39 %) and better parent heterosis (-31.58 %) and standard heterosis (-29.73 %) in negative direction. Similarly, AT-382 with VRI-1 showed highest mid parent heterosis (-11.80 %) and better parent heterosis (-20.22 %) in negative direction whereas AT-382 with Uma resulted in highest heterosis over check variety. Significant amount of heterosis in negative direction for days to 50% flowering and days to maturity was reported by Sundari and Kamala (2012), Salunke et al. (2013) and Virani et al. (2017). This is due to involvement of AT-382 in crossing programme which is an early maturing variety.

Plant height is an important character that majorly contributes for yield (Kante et al., 2022). In this experiment, highest amount of relative heterosis (51.31%) for plant height was observed in cross Prachi with Uma, highest hetero-beltiosis (43.27%) in cross of AT-382 with GT-10 and standard heterosis in cross (23.94%) VRI-1 with Uma. Varied amount of significant heterosis for plant height in positive direction has been observed by various scientist. Salunke et al. (2013), Azeez and Morakinyo (2014) reported 20% to 50% heterosis in cross combination over mid-parent and better parent. Moderate amount of significant of relative heterosis, heterobeltiosis and standard heterosis was reported by Virani et al. (2017) and Chauhan et al. (2019b). This varied amount of heterosis is the result of cross combination with differed plant height of parent as plant height indirectly related with yield via days to maturity, number of branches and number of capsules (Ukaan and Ogbonna, 2012). More plant height may impose negative impact on yield due to susceptible to lodging, so cross exhibited moderate heterosis for plant height combining with other desirable traits always preferable for better yield. Plant height up to 1st branching and plant height up to 1st capsule bearing node is the least studied trait in sesame improvement. In our previous study, we have reported that Plant height up to 1st branching showed significant positive correlation with plant height up to 1st capsule bearing node and capsule per plant, however plant height up to 1st capsule bearing node showed significant positive correlation with capsules per plant and yield per plant (Kabi et al., 2020). So inclusion of these two high yields contributing character for identification of best heterotic cross is rewarding for development of hybrid variety. In this present experiment, we observed that AT-382 with Uma exhibited highest heterosis relative heterosis for Plant height up to 1st branching (78.57%), whereas Rama with Prachi exhibited highest relative heterosis for Plant height up to 1st capsule bearing node (55.40 %).

Branches per plant is highly corelated with important yield component traits i.e. number capsules/plant, capsule breadth, capsule length, number of seeds per capsule and seed weight. So cross that produced highest branches per plant can be selected for development of hybrid for high yield. In this study, twelve crosses revealed significant positive relative heterosis, seven crosses showed significant positive heterobeltiosis and five crosses exhibited significant positive standard heterosis for this character. GT-10 with Krishna showed highest heterosis over mid-parent (130.21%), over better parent (115.10%) and over check variety (84.37%).

Superior cross combination with different parent for relative heterosis and heterobeltiosis were reported by Prajapati et al. (2010), Parimala et al. (2013), Azeez & Morakiny (2014) and Virani et al. (2017). Distance between two nodes inversely related with number of capsules per plant. So heterosis in negative direction is desirable for selection of desirable cross. AT-382 with Krishna showed highest relative heterosis (-46.13%) in negative direction whereas with GT-10 produced highest heterobeletosis (-48.23 %) in negative direction.

Table 3: Estimation of heterosis percentage for fourteen characters in F1 generation of sesame

Cross No.	Characters/ Crosses	Days to 50% flowering			Days to maturity			Plant height			Plant height up to1st branching		
		RH	HB	SH	RH	HB	SH	RH	HB	SH	RH	HB	SH
1	Rama× AT-382	-22.39**	-31.58**	-29.73**	-8.28**	-15.29**	-13.25**	16.30**	-1.49	0.68	34.67	-11.34	12.42
2	Rama×VRI-1	-11.11**	-15.79**	-13.51**	-2.30	-4.49**	2.41	5.17	-0.65	1.55	17.87	3.51	31.24
3	Rama×GT-10	-17.33**	-18.42**	-16.22**	-2.07	-5.80**	4.42**	23.74**	8.06	10.44*	38.06*	10.52	40.13
4	Rama×Krishna	-16.67**	-21.05**	-18.92**	-4.19**	-5.88**	-3.61*	14.01**	4.73	7.04	-10.27	-12.58	10.85
5	Rama×Nirmala	-14.67**	-15.79**	-13.51**	-4.76**	-5.88**	-3.61*	8.17	7.00	9.36	21.96	9.07	38.30
6	Rama×Prachi	-15.69**	-24.56**	-22.52	-4.82**	-7.06**	-4.82**	33.64**	9.20	11.61*	14.19	1.24	28.37
7	Rama×Uma	-17.65**	-26.32**	-24.32**	13.06**	12.40**	16.47**	14.96**	5.12	7.44	22.29	-1.03	25.49
8	AT-382×VRI-1	-17.46**	-23.53**	-29.73**	-11.80**	-20.22**	-14.46**	33.97**	19.25**	8.41	42.60	1.16	-3.01
9	AT-382× GT-10	6.06	-5.41	-5.41	-8.54**	-18.48**	-9.64**	48.50**	43.27**	9.33	43.35	9.45	-16.60
10	AT-382× Krishna	-6.88	-13.73**	-20.72**	-3.90*	-9.76**	-10.84**	38.02**	26.22**	8.00	12.03	-25.28	-10.13
11	AT-382× Nirmala	-15.15**	-24.32**	-24.32**	-7.10**	-13.25**	-13.25**	24.05**	6.02	6.02	36.54	-4.31	-4.31
12	AT-382×Prachi	-8.47	-10.00*	-27.03**	-0.65	-6.17**	-8.43**	45.81**	39.53**	-1.02	36.59	-3.73	-5.62
13	AT-382×Uma	-11.86**	-13.33**	-29.73**	24.05	13.95**	18.07**	33.94**	23.05**	4.24	78.57*	35	5.88
14	VRI-1×GT-10	-4.23	-8.11*	-8.11*	-0.55	-2.17	8.43**	29.54**	19.14**	8.31	37.12	23.04	17.97
15	VRI-1×Krishna	-2.94	-2.94	-10.81**	-7.60**	-11.24**	-4.82**	34.80**	30.85**	18.95**	-24.49	-32.15	-18.39
16	VRI-1× Nirmala	-15.49**	-18.92**	-18.92**	-5.43**	-8.61**	-2.01	16.96**	11.64*	11.64*	56.62**	53.40*	53.40*
17	VRI-1 × Prachi	-9.38*	-14.71**	-21.62**	-1.18	-5.62**	1.20	33.21**	14.11*	3.73	54.77**	53.07*	50.07*
18	VRI-1 × Uma	-12.50**	-17.65**	-24.32**	14.29**	12.36**	20.48**	41.15**	36.34**	23.94**	-18.26	-25.70	-28.76
19	GT-10×Krishna	-18.31**	-21.62**	-21.62**	0.00	-5.43**	4.82**	46.98**	39.03**	18.96**	-16.85	-32.08	-18.31
20	GT-10×Nirmala	-5.41	-5.41	-5.41	-7.43**	-11.96**	-2.41	29.73**	14.36**	14.36**	15.14	1.44	1.44
21	GT-10× Prachi	9.45*	-0.90	-0.90	-2.89*	-8.70**	1.20	50.28**	38.98**	6.05	36.24	21.07	18.69
23	GT-10× Uma	-16.42**	-24.32**	-24.32**	-1.12	-4.35**	6.02**	43.68**	36.55**	15.68**	44.73	42.67	11.90
23	Krishna× Nirmala	-9.86**	-13.51**	-13.51**	-4.24**	-4.82**	-4.82**	19.09**	10.50**	10.50*	7.53	-1.53	18.43
24	Krishna× Prachi	9.38*	2.94	-5.41	0.61	-	-1.20	38.48**	21.70**	4.14	37.24*	24.55	49.80*
25	Krishna×Uma	-10.42*	-15.69**	-22.52**	5.95**	3.49*	7.23**	33.30**	32.64**	13.50**	52.36**	25.86	51.37*
26	Nirmala×Prachi	-7.46	-16.22**	-16.22**	-1.22	-2.41	-2.41	39.25**	14.77**	14.77**	17.76	16.60	16.60
27	Nirmala ×Uma	-10.45**	-18.92**	-18.92**	-1.78	-3.49*	-	20.46**	11.26**	11.26*	40.37	25.23	25.23
28	Prachi×Uma	-	-	-18.92**	-1.80	-4.65**	-1.20	51.31**	33.55**	13.14*	65.33**	48.80*	45.88*

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Cross No.	Characters/ Crosses	Plant height up to1st Capsule bearing node			Branches per plant			Internode length			Capsules per plant		
		RH	HB	SH	RH	HB	SH	RH	HB	SH	RH	HB	SH
1	Rama× AT-382	31.99**	9.87	8.74	-11.71	-22.22	-12.50	5.24	-11.99	12.30	-8.00	-27.37**	-13.75
2	Rama×VRI-1	33.50**	31.67**	30.31**	10.77	-14.29	-3.57	-34.51	-42.34	-34.96	3.99	-19.30*	-4.17
3	Rama×GT-10	29.94**	28.12**	26.80**	13.51	-	12.50	-34.21	-38.74	-39.02	44.95**	18.25*	40.42**
4	Rama×Krishna	5.55	-1.81	31.84**	12.70	-6.35	5.36	-40.84*	-49.01**	-39.53	11.60	-8.68	8.44
5	Rama×Nirmala	32.52**	31.84**	28.66**	15.97	9.52	23.21	-41.48*	-45.63*	-45.63*	17.33*	8.07	28.33**
6	Rama×Prachi	55.40**	30.00**	24.48**	46.22*	20.63	35.71	-10.58	-13.33	-20.73	9.09	-5.26	12.50
7	Rama×Uma	28.24**	25.77**	24.48**	-3.43	-9.52	1.79	-6.10	-23.03	-33.94	-13.40	-29.33**	-16.08
8	AT-382×VRI-1	53.63**	29.33**	14.45	96.36**	68.75**	44.64*	-44.20	-47.43**	-32.93	33.40*	30.30*	-10.42
9	AT-382× GT-10	41.31**	18.98**	-3.72	66.67**	66.67*	42.86	-41.83*	-48.23**	-33.94	32.17**	26.67*	-5.00
10	AT-382× Krishna	6.49	-16.29*	18.89*	79.49**	67.71*	43.75	-46.13**	-48.03**	-33.69	98.05**	89.11**	42.92**
11	AT-382× Nirmala	43.42**	18.89*	1.48	46.15*	35.71	35.71	-24.98	-33.09*	-14.63	51.01**	27.42**	27.42**
12	AT-382×Prachi	53.27**	52.33**	2.53	39.40	29.17	10.71	-35.51*	-44.64**	-29.37	16.80	4.29	-8.75
13	AT-382×Uma	27.39**	7.73	23.92**	31.97	23.52	21.43	-18.69	-41.86*	-25.81	35.59**	29.89*	-2.50
14	VRI-1×GT-10	28.79**	28.75**	32.98**	33.33	14.58	-1.79	-36.20*	-39.95*	-32.27	12.25	5.18	-21.11*
15	VRI-1×Krishna	27.78**	17.35*	38.62**	62.73*	48.68	10.71	-25.78	-27.59	-14.13	37.57**	28.46*	-2.92
16	VRI-1× Nirmala	41.27**	38.62**	25.05**	32.60	7.14	7.14	-23.59	-27.93	-18.70	10.00	-8.94	-8.94
17	VRI-1 × Prachi	53.56**	29.92**	29.74**	31.88	21.49	-11.16	-7.46	-16.22	-5.49	-1.57	-13.90	-24.67*
18	VRI-1 × Uma	35.56**	34.80**	23.98**	101.01**	63.49**	60.71**	34.55	-	12.80	102.67**	89.84**	42.50**
19	GT-10×Krishna	17.40*	7.79	24.22**	130.21**	115.10**	84.37**	-20.43	-26.82	-13.21	66.58**	65.95**	25.42*
20	GT-10×Nirmala	26.63**	24.22**	24.73**	69.23**	57.14*	57.14*	-9.85	-10.06	-10.06	43.52**	25.58*	25.58*
21	GT-10× Prachi	53.22**	29.67**	18.64*	43.90	33.33	14.29	2.15	-1.99	-2.44	69.23**	57.14**	37.50**
23	GT-10× Uma	24.00**	23.33*	18.89*	51.38*	41.69	39.29	36.89	6.18	5.69	72.29**	72.22**	29.27**
23	Krishna× Nirmala	10.59	3.37	20.04*	56.91*	36.88	36.88	25.52	15.68	37.20	90.23**	67.00**	67.00**
24	Krishna× Prachi	32.17**	4.36	24.73**	35.51	34.29	-	-3.73	-14.74	1.12	-8.84	-15.05	-25.67*
25	Krishna×Uma	18.69*	8.45	20.16*	32.30	16.26	14.29	12.48	-17.74	-2.44	58.08**	57.54**	19.06
26	Nirmala×Prachi	44.24**	20.16*	31.20**	100.10**	73.21**	73.21**	0.85	-3.46	-3.46	74.89**	63.96**	63.96**
27	Nirmala ×Uma	34.45**	31.20**	31.20**	17.06	16.07	16.07	36.48	5.69	5.69	13.77	-0.42	-0.42
28	Prachi×Uma	55.29**	32.00**	25.62**	31.25	14.44	12.50	18.06	-5.56	-13.62	48.66**	38.10**	20.83*

Cross No.	Character/ Cross	Seeds per capsule			Capsule length			Capsule width			100-seed weight		
		RH	HB	SH	RH	HB	SH	RH	HB	SH	RH	HB	SH
1	Rama× AT-382	11.97**	9.62	5.24	10.64**	8.33	-2.92	16.94**	15.05*	6.47	-3.68	-6.22	-19.05**
2	Rama×VRI-1	0.63	-4.76	-8.57	10.61**	5.80	-8.86*	24.29**	22.22**	9.45	-12.74**	-14.15**	-27.46**
3	Rama×GT-10	8.07	1.19	-2.86	3.02	1.45	-12.61**	-7.18	-13.81*	-9.95	-9.90**	-17.08**	-19.35**
4	Rama×Krishna	2.73	-2.78	-6.67	8.87*	5.80	-8.86*	17.26**	9.44	-1.99	-11.71**	-16.70**	-23.20**
5	Rama×Nirmala	10.79*	8.57	8.57	12.01**	4.24	4.24	10.24	4.48	4.48	-18.62**	-26.04**	-26.04**
6	Rama×Prachi	19.50**	13.10*	8.57	6.94	0.77	-1.87	6.57	-2.31	4.98	14.12**	6.69	-12.77**
7	Rama×Uma	21.30**	20.59**	17.14	16.00**	7.41	8.61*	-9.04	-14.98*	-12.44	5.62	1.96	-10.44**
8	AT-382×VRI-1	18.99**	14.94*	5.71	25.93**	18.06**	6.12	36.67**	32.26**	22.39**	0.24	-0.82	-14.39**
9	AT-382× GT-10	10.50	5.62	-2.86	20.95**	16.67**	4.87	23.74**	16.67**	21.89**	-7.28*	-12.50**	-14.89**
10	AT-382× Krishna	13.63*	9.76	0.95	17.14**	11.53**	0.25	29.82**	19.35**	10.45	-5.22	-8.24*	-15.40**
11	AT-382× Nirmala	23.03**	18.10**	18.10**	9.93**	4.37	4.37	17.31**	12.94*	12.94*	-11.80**	-17.83**	-17.83**
12	AT-382×Prachi	17.92**	13.90*	4.76	8.00*	3.85	1.12	-2.99	-9.72	-2.99	13.90**	3.87	-10.33**
13	AT-382×Uma	10.79	7.84	4.76	10.98**	4.81	5.99	15.52**	9.66	12.94*	2.04	1.15	-11.14**
14	VRI-1×GT-10	12.38*	11.11	-4.76	11.62**	8.37	-9.49*	-1.04	-9.52	-5.47	-12.15**	-17.92**	-20.16**
15	VRI-1×Krishna	11.11	11.11	-4.76	23.81**	21.81**	-1.00	19.39**	13.22	-1.99	-16.63**	-20.11**	-26.34**
16	VRI-1× Nirmala	-1.54	-8.57	-8.57	-1.75	-12.23**	-12.23**	1.33	-5.47	-5.47	-20.48**	-26.65**	-26.65**
17	VRI-1 × Prachi	13.33*	13.33	-2.86	1.42	-8.33*	-10.74**	-5.64	-14.81*	-8.46	5.60	-2.76	-17.83**
18	VRI-1 × Uma	6.25	0.00	-2.86	9.72**	-2.47	-1.37	-5.51	-13.04*	-10.45	-19.69**	-21.22**	-30.80**
19	GT-10×Krishna	25.86**	24.44**	6.67	16.67**	15.10**	-3.87	1.09	-11.90	-7.96	-18.72**	-20.83**	-23.00**
20	GT-10×Nirmala	12.97*	3.81	3.81	7.48*	-1.37	-1.37	5.11	2.86	7.46	-17.93**	-19.05**	-19.05**
21	GT-10× Prachi	10.13	8.89	-6.67	7.66*	0.00	-2.62	-10.80*	-12.04	-5.47	-14.08**	-25.63**	-27.66**
23	GT-10× Uma	14.75*	6.86	3.81	-1.96	-10.49**	-9.49	-2.78	-3.48	0.85	-18.56**	-22.50**	-24.62**
23	Krishna× Nirmala	24.10**	15.24*	15.24*	15.70**	4.87	4.87	-2.52	-13.43*	-13.43*	-11.54**	-14.99**	-14.99**
24	Krishna× Prachi	26.67**	26.67**	8.57	10.83**	1.67	-1.00	-10.22	-22.69**	-16.92**	-4.34	-15.27**	-21.88**
25	Krishna×Uma	4.17	-1.96	-4.76	11.16**	0.25	1.37	5.79	-7.25	-4.48	-6.70*	-8.90*	-16.01**
26	Nirmala×Prachi	24.10**	15.24*	15.24*	7.02*	5.62	5.62	-15.11**	-18.06**	-11.94	-15.33**	-27.56**	-27.56**
27	Nirmala ×Uma	11.69*	10.10	10.10	1.18	0.62	1.75	-0.49	-1.93	1.00	-8.31*	-13.88**	-13.88**
28	Prachi×Uma	22.92**	15.69*	12.38*	-0.13	-1.98	0.87	-4.02	-6.02	1.00	1.21	-8.42*	-19.55**

Table 4: Over-all mean performance of 8 parents and 28 crosses for fourteen characters in F1 generation

Cross No.	Character/ Crosses	Seed Yield per plant			Oil percentage		
		RH	HB	SH	RH	HB	SH
1	Rama×AT-382	17.17	-	-23.93**	-35.00**	-42.22**	-27.78**
2	Rama×VRI-1	3.79	-14.42	-34.90**	-24.31**	-35.67**	-10.65
3	Rama×GT-10	42.88**	38.25**	5.16	5.79	-7.81	-10.37
4	Rama×Krishna	26.44**	10.14	-16.22*	-16.32	-19.90*	-22.13*
5	Rama×Nirmala	11.02	-2.27	-2.27	-9.01	-10.28	-10.28
6	Rama×Prachi	40.06**	27.96**	-2.67	3.23	-2.67	-5.37
7	Rama×Uma	24.35*	10.82	-15.70*	-13.81	-13.81	-16.20
8	AT-382×VRI-1	42.56**	31.58*	-23.20**	-22.11**	-26.00**	2.78
9	AT-382 ×GT-10	30.92**	19.17	-15.23*	-9.01	-28.22**	-10.28
10	AT-382×Krishna	92.46**	89.32**	33.27**	27.53**	9.11	36.39**
11	AT-382×Nirmala	57.42**	24.65**	24.65**	-22.88**	-30.59**	-13.24
12	AT-382×Prachi	38.60**	33.58**	-15.95*	-28.86**	-39.93**	-24.91**
13	AT-382×Uma	55.66**	54.17**	-8.25	3.08	-8.37	14.54
14	VRI-1×GT-10	8.93	-7.73	-34.37**	-23.25**	-41.67**	-18.98*
15	VRI-1×Krishna	39.64**	30.87*	-26.11**	0.24	-17.80**	14.178
16	VRI-1×Nirmala	-15.21	-36.68**	-36.68**	20.93**	4.00	44.44**
17	VRI-1×Prachi	27.57*	13.83	-28.38**	33.33**	8.00	50.00**
18	VRI-1×Uma	69.43**	54.99**	-7.76	-12.78	-25.87**	2.96
19	GT-10×Krishna	53.27**	37.46**	-2.22	0.57	-8.885	-18.98*
20	GT-10×Nirmala	32.00**	12.94	12.94	-18.82*	-30.09**	-30.09**
21	GT-10 ×Prachi	45.88**	37.46**	-2.22	12.98	3.87	-10.56
23	GT-10×Uma	40.11**	28.67**	-8.48	8.20	-5.71	-8.33
23	Krishna×Nirmala	64.76**	28.89**	28.89**	-15.39	-20.09*	-20.09*
24	Krishna×Prachi	-3.77	-8.71	-42.56**	-19.79*	-21.04*	-29.81**
25	Krishna×Uma	68.90**	64.57**	-2.06	58.21**	51.43**	47.22**
26	Nirmala×Prachi	63.60**	33.27**	10.50	34.33**	25.00**	25.00**
27	Nirmala×Uma	23.47**	-1.53	-1.53	18.31*	16.67	16.67
28	Prachi×Uma	79.85**	74.97**	10.09	27.27**	20.00*	16.67

N.B.: * and ** indicate significance at 5% and 1% levels of probability respectively, RH: Relative heterosis, HB: Heterobeltiosis, SH: Standard Heterosis

Capsules per plant is directly corelated with yield. So cross showing highest heterosis can be selected for high yield. Highest percentage of relative heterosis (102.67%) and heterobeltiosis (89.84%) has exhibited by VRI-1 with Rama, However Krishna with Nirmala showed highest heterosis (67%) over standard check. Out of twenty-eight crosses, seventeen crosses showed significant positive relative heterosis, heterobeltiosis and standard heterosis. Superior crosses for this character reported by Prajapati et al. (2010), Parimala et al. (2013), Azeez and Morakiny (2014) and Virani et al. (2017).

For seeds per capsule, eighteen crosses showed significant positive relative heterosis, ten crosses exhibited significant positive heterobeltiosis and four crosses revealed significant positive standard heterosis this character. Highest relative heterosis exhibited by Krishna with Prachi (26.67%), however GT-10 with Krishna showed highest heterosis (26.67%) over better parent. Superior cross over better parent reported by Prajapati et al. (2010) and over mid parent was reported by Salunke et al. (2013), Virani et al. (2017) and Chauhan et al. (2019b). This differed result due to different parent included in cross combination. Capsule length and capsule width are two characters that is indirectly corelate with yield. AT-382 with VRI-1 showed highest relative heterosis for both the character. Capsule width is most often associated higher seed dimension particularly seed length. AT-382 with VRI-I, also exhibited highest heterosis over better parent (32.26%) and over check variety (22.39%) for capsule width. Highest heterosis (21.81%) over better parent, exhibited by the cross combination of VRI-1 with Krishna. Virani et al. (2017) and Chauhan et al. (2019b) studied heterosis for capsule length and capsule width with different parent and reported superior cross combination for this character.

Seed yield is the wholesome expression of all the agroeconomic traits in a crop. In the present study, 22 crosses revealed significant positive relative heterosis, 16 crosses showed significant positive heterobeltiosis but only 3 crosses revealed significant positive standard heterosis for this character. AT-382 with Krishna produced highest heterosis over mid-parent (92.46%), highest heterosis over better parent (89.32%) and also highest heterosis over check variety (33.27 %). Varied percentage of heterosis showed by various parental combination for all type of heterosis has been reported by Gaikwad and Lal (2011), Sundari and Kamala (2012), Salunke et al. (2013), Virani et al. (2017), Chauhan et al. (2019), Daba et al. (2019) and Dela and Sharama (2019). In some observation, the cross that produced highest relative heterosis for yield not showed highest heterosis over better parent and standard check variety (Chaudhari et al. 2017). This is due to different genetic background of parent involved in cross combinations. Oil content of sesame varied from 45% to 57% which is the highest among all major oil seed crop. As reported, potentiality to increase the oil percentage up to 60%, estimation of heterosis for oil percentage is the pre-requisites for identification of suitable cross for high oil content (Wei et al., 2022). In this study, Krishna with Uma showed highest heterosis (58.21%) over mid-parent, over better parent (51.43%) and over standard check (47.22%). Interestingly, we recorded significant positive relative heterosis in seven crosses, heterobeltiosis in three elite crosses and even standard heterosis in five crosses for oil content. Banerjee and Kole (2011), Salunke et al. (2013) and Virani et al. (2017) also achieved similar heterotic performance for such a quality trait.

CONCLUSION

Present study was conducted for identification of potential heterotic cross for development of hybrid. Here, we have identified potential cross combination for each fourteen characters studied, that described in discussion. However, keeping in importance of the trait and percentage of heterosis, we identified three best cross; AT-382 × VRI-1 for early maturity, AT-382 × Krishna topped among all cross for seed yield per plant and Krishna × Uma identified as the best cross for oil percentage. These three crosses could be used as valuable hybrids for sesame cultivation with a view to meet the requirement of the farming community.

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