The Pharma Innovation Journal 2023; 12(7): 2747-2750

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(7): 2747-2750

www.thepharmajournal.com
Received: 08-04-2023
Accepted: 11-05-2023

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Heterosis for quantitative traits in white seeded sesame (*Sesamum indicum* L.)

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Abstract
The evaluation of the extent of heterosis of 12 characters in 15 hybrids of sesame obtained by crossing 5 lines and 3 testers in line x tester method was performed at farmers field, ORARS (KAU) Kayamkulam. Highly significant variations were visible for all of the genotype characters when analysis of variance was done. The spectrum of standard heterosis for seed yield plant^{-1} ranged from -69.46% to 78.57%. The five hybrids *viz*., Gu. Til 4 x NIC-8322, Gu. Til 4 x PCU-41, RT-346 x PCU-37, VRI-3 x PCU-41 and Punjab Til No.2 x PCU-37 recorded significant positive standard heterosis over the check for seed yield plant^{-1}.

Keywords: Sesame, relative heterosis, heterobeltiosis, standard heterosis

1. Introduction

Sesame (*Sesamum indicum* L.), possess higher nutritive value and keeping quality which makes it an important source of edible oil. In the international market, the superior quality of sesame oil and the confectionary value of its seed have helped it to emerge as a prominent commodity. Sesame seeds are generally of 3 main colours: White, Black and Brown. The development of white seeded sesame varieties that possess durable lustre has gained a lot of recognition in most of the prominent sesame cultivating nations including India. Physical outlook of the seed colour is a prominent marketing criterion and cultural preferences also play a key role in the acceptability of sesame type. White coloured sesame is typically chosen for preparing bakery and confectionary products. Additionally, compared to black seeded sesame, it is reported to have higher oil, protein, linoleic acid, and moisture ratios (Kanu, 2011) [3]. The white varieties of sesame elicit better antioxidant activity than the black ones (Vishwanath *et al.,* 2012) [15]. The uniform, shiny, white, and bold seed with high lignan content (>830 mg/100 g seed), low free fatty acid content (<2), low oxalic acid concentration (<1), and free from insect pests and pesticide residue is favored for export (Kumaraswamy *et al*., 2015) [6]. Even though the white seeded sesame is getting an ameliorating demand recently, high yielding varieties with sufficient oil content are very scarce in Kerala compared to black seeded varieties.

Most of the high yielding varieties in sesame were developed through hybridization followed by selection. Hence, heterosis breeding appears to be promising in achieving the yield breakthrough. Successful exploitation of heterosis require two basic prerequisites namely significant heterotic effect must be present and production of large-scale hybrid seed should be possible. The information on the magnitude of heterosis is very essential in the development of hybrids. Thus, the crucial step in heterosis breeding is effective selection of parents for identifying heterotic crosses. It is easy for hand emasculation and pollination in sesame; and also, single crossed capsule gives a greater number of seeds. So, in sesame heterosis breeding can be largely exploited. The exploitation of hybrid vigour as a mean of maximizing the yield of agricultural crops has become one of the outstanding ways to increase productivity of it.

2. Materials and Methods

The experiment was carried out at farmers field, ORARS (KAU) Kayamkulam, Alappuzha, Kerala. Five diverse lines with high yield *viz*., Gu. Til 4, VRI-3, Punjab Til No.2, RT-346 and PCU-42 and three testers with high oil content *viz*., PCU-37, PCU-41 and NIC-8322 were crossed in a line × tester mating design during 2020-2021 to produce fifteen hybrids. The seeds were produced by hand pollination. The resulting fifteen F_1 hybrids along with their eight parents (23 treatments) and a check variety, SVPR1 were evaluated during summer

2021-2022 in a Randomized Block Design with three replications. The plot size was 1.5 m^2. In each replication, parents and F_1 hybrids were sown in five rows with a spacing of 30 cm between rows and 15 cm between plants in a row. Recommended agronomic practices were ensured to be followed during the period of crop growth, as per the "Package of Practices recommendations" of the agricultural university in Kerala (KAU, 2016) [4].

The observations were recorded for the following twelve quantitative traits *viz*., days to 50 per cent blooming, maturity days, height of the plant, primary branches plant^{-1}, number of capsules per leaf axil, number of capsules plant^{-1}, capsule length (cm), number of seeds capsule^{-1}, 1000 seed weight, leaf area (cm^2), dry matter production and seed yield plant^{-1}. The analysis of variance (mean square) for line x tester design was performed to test the significance of difference among the genotypes for seed yield and its contributing characters in sesame based on the statistical model suggested by Panse and Sukhatme (1967) [8]. The heterotic effects were computed as the percentage increase (+) or decrease (-) of F1 mean values over mid parent (relative heterosis), better parent (heterobeltiosis) and standard check variety (standard heterosis) was estimated and its significance was tested using formulae suggested by Turner (1953) [13].

3. Results and Discussions

Analysis of variance for parents, crosses and parent *vs* crosses are presented in Table 1. The differences were significant and it suggested the adequate heterogeneity among the parents and progenies. The out turn of this research is in tune with the findings of Sirohi *et al.* (2020) [12] for days for 50 per cent blooming, maturity days, capsule length, number of capsules plant^{-1} and seed yield plant^{-1}. The mean squares due to parents *vs* hybrids were found significant for all the characters except days for 50 per cent blooming, maturity days and number of seeds capsule^{-1} indicating that heterosis could be exploited for most of the characters under study.

Information on the magnitude of heterosis is a pre-requisite to filter out the most efficient combination of parents that can provide a higher degree of useful heterosis for seed yield and yield attributing characters. An ideal hybrid needs to show higher amount of heterosis for commercial benefit. Developing better hybrids with the use of stable and high yielding parents will raise the yield ceiling of sesame. In order to obtain high yielding cross combinations, it is vital to assess hybrid combinations for seed yield and its constituents. In the current investigation, per cent increase or decrease over mid parent, better parent (heterobeltiosis) and standard check, SVPR1 (Standard heterosis) was used as a measure of heterosis. In Table 2, the range of relative heterosis (RH), heterobeltiosis (HB), and standard heterosis (SH), as well as the number of crosses exhibiting responses to heterotic effects for various attributes in sesame, are shown.

The range of relative heterosis for days to 50 percent blooming varied from -15.63% to 27.18%. None of the crosses showed the standard heterosis in a desired (positive) direction. The spectrum of standard heterosis for maturity days ranged from -8.63% to 11.76%. The characters such as height of the plant and primary branches per plant exhibited standard heterosis upto 15.18% and 45.33%, respectively. Similar results have been reported by Virani *et al*. (2017) [14], Parameshwarappa *et al*. (2021) [9] and Kumar *et al*. (2022) [5]. For number of capsules per leaf axil, only four crosses depicted significant and desired standard heterosis. Out of the fifteen crosses, ten and six crosses showed significant positive standard heterosis for the number of capsules per plant and capsule length. In the case of number of seeds per capsule, value of standard heterosis was in between -23.90% and 25.86% and five crosses reported significant and positive standard heterosis. Parimala *et al*. (2013) [10], Oza Hely *et al.* (2020) [7] and Rathod *et al*. (2021) [11] also reported significant positive heterosis for this trait. The heterobeltiosis for 1000 seed weight ranged from -22.73% to 21.67%. These findings are in consonance with El-Kader *et al.*, (2017) [1] and Kumar *et al.* (2022) [5]. The hybrid vigour for leaf area over the standard check varied from -82.18% to 48.71% and was recorded in two out of fifteen crosses. The heterobeltiosis for the trait dry matter production varied from -51.93% to 74.50%. The extent of relative heterosis and heterobeltiosis for seed yield ranged from -51.97% to 208.71% and -62.43% to 124.24% respectively. Imran *et al.* (2017) [2] also reported highest degree of relative heterosis and heterobeltiosis for seed yield. The highest magnitude of standard heterosis for seed yield was recorded in five out of fifteen crosses *viz.*, Gu. Til 4 x NIC-8322 (78.57%) followed by Gu. Til 4 x PCU-41 (61.41%), RT-346 x PCU-37 (36.25%), VRI-3 x PCU-41 (31.97%) and Punjab Til No.2 x PCU-37 (27.04%). Significant positive standard heterosis for seed yield per plant in sesame has been reported by Imran *et al.* (2017) [2], Virani *et al.* (2017) [14], Oza Hely *et al.* (2020) [7], Rathod *et al.* (2021) [11] and Kumar *et al.* (2022) [5]. Virani *et al.* (2017) [14] also reported significant standard heterosis for the traits *viz.*, maturity days, height of the plant, number of branches plant^{-1}, capsule length, number of capsules plant^{-1}, number of capsules per leaf axil, number of seeds capsule^{-1} and 1000 seed weight along with seed yield plant^{-1}.

Table 1: Analysis of variance (mean square) for line x tester design for seed yield and its contributing characters in white seeded sesame

Sources	**DF**	**Mean squares for**											
		Days for 50 percent blooming	**Maturity days**	**Height of the plant (cm)**	**Primary branches plant^{-1}**	**Number of capsules per leaf axil**	**Number of capsules plant^{-1}**	**Capsule length (cm)**	**Number of seeds capsule^{-1}**	**1000 seed weight (g)**	**Leaf area (cm^2)**	**Dry matter production**	**Seed yield plant^{-1} (g)**
Replication	2	0.275	0.565	18.061	0.475	0.012	73.59	0.018	22.449	0.004	6189.938	8.572	14.486
Treatments	22	53.179**	50.984**	966.924**	6.359**	1.089**	2105.069**	0.119**	216.097**	0.344**	9433003.378**	756.437**	188.470**
Parents	7	91.042**	22.280*	790.207**	3.636**	0.722**	893.537**	0.114**	112.833**	0.286**	7730421.522**	228.645**	50.999**
Parents *vs* Crosses	1	0.873	1.383	2065.802**	13.136**	0.398**	6759.824**	0.005**	0.978	0.085*	15851193.870**	2016.865**	328.553**
Crosses	14	37.984**	68.879**	976.791**	7.236**	1.323**	2378.352**	0.130**	283.095**	0.391**	9825852.129**	930.303**	247.199**
Error	44	12.306	9.247	77.051	0.251	0.007	80.197	0.012	22.313	0.02	53584.783	18.435	5.469

** Significant at 1 percent level

* Significant at 5 percent level

Table 2: Range of heterosis as well as number of crosses with response to heterotic effects for various traits in sesame

Sl. No.	Characters	Range of heterosis			No. of crosses with significant heterosis					
		RH	HB	SH	RH		HB		SH	
					+ve	-ve	+ve	-ve	+ve	-ve
1.	Days for 50 per cent blooming	-15.63 – 27.18	-23.94 – 26.53	-30.07 - 0.76	01	01	01	03	00	12
2	Maturity days	-7.78 - 10.4	-10.23 - 8.78	-8.63 - 11.76	03	04	02	04	02	02
3	Height of the plant (cm)	-6.66 - 31.34	-14.43 - 24.42	-20.21 - 15.18	06	00	06	05	03	04
4	Primary branches plant^{-1}	-48.72 - 130.99	-65.1 - 104.74	-68 - 45.33	07	02	06	03	02	07
5	Number of capsules per leaf axil	-6.25 - 60.78	-11.50 - 13.89	0.00 - 173.33	04	00	03	00	04	00
6	Number of capsules plant^{-1}	-17.39 - 141.99	-39.88 - 90.91	-44.65 - 47.97	10	00	05	02	03	08
7	Capsule length (cm)	-18.92 - 15.41	-23.08 - 11.11	-9.85 - 17.68	06	02	03	03	05	02
8	Number of seeds capsule^{-1}	-19.81 - 26.02	-22.73 - 21.67	-23.90 - 25.86	05	04	02	06	05	03
9	1000 seed weight	-22.55 - 38.07	-25.12 - 34.29	-18.25 - 16.82	06	04	02	05	05	04
10	Leaf area	-67.70 - 81.44	-76.78 - 35.92	-82.18 - 48.71	05	10	04	10	02	12
11	Dry matter production	-34.56 - 123.64	-51.93 - 74.50	-55.71 - 42.92	07	02	07	04	05	07
12	Seed yield plant^{-1}	-51.97 - 208.71	-62.43 - 124.24	-69.46 - 78.57	06	03	06	05	05	09

Table 3: Per centage of relative heterosis (RH) heterobeltiosis (HB) and standard heterosis (SH) for seed yield plant^{-1}

Sl. No.	Hybrids	Seed yield plant^{-1}		
		RH	HB	SH
1	Gu. Til 4 x PCU-37	7.00	-30.95**	-34.71**
2	Gu. Til 4 x PCU-41	123.52**	70.71**	61.41**
3	Gu. Til 4 x NIC-8322	162.69**	88.87**	78.57**
4	VRI-3 x PCU-37	-43.61*	-62.43**	-68.92**
5	VRI-3 x PCU-41	99.02**	59.49**	31.97**
6	VRI-3 x NIC-8322	76.04**	32.07*	9.28
7	Punjab Til No.2 x PCU-37	175.24**	95.99**	27.04*
8	Punjab Til No.2 x PCU-41	18.04	4.43	-32.31**
9	Punjab Til No.2 x NIC-8322	15.45	-5.40	-38.68**
10	RT-346 x PCU-37	208.71**	124.24**	36.25**
11	RT-346 x PCU-41	-33.02*	-39.01*	-62.94**
12	RT-346 x NIC-8322	8.14	-9.06	-44.75**
13	PCU-42 x PCU-37	32.76	-9.97	-30.43**
14	PCU-42 x PCU-41	-51.97**	-60.48**	-69.46**
15	PCU-42 x NIC-8322	-23.61	-41.32**	-54.66**
	S.E.	1.65	1.91	1.91
	CD at 5%	3.33	3.86	3.86
	CD at 1%	4.44	5.14	5.14
	Range	-51.97 - 208.71	-62.43 - 124.24	-69.46 - 78.57
	No. of crosses in desirable direction	6	6	5

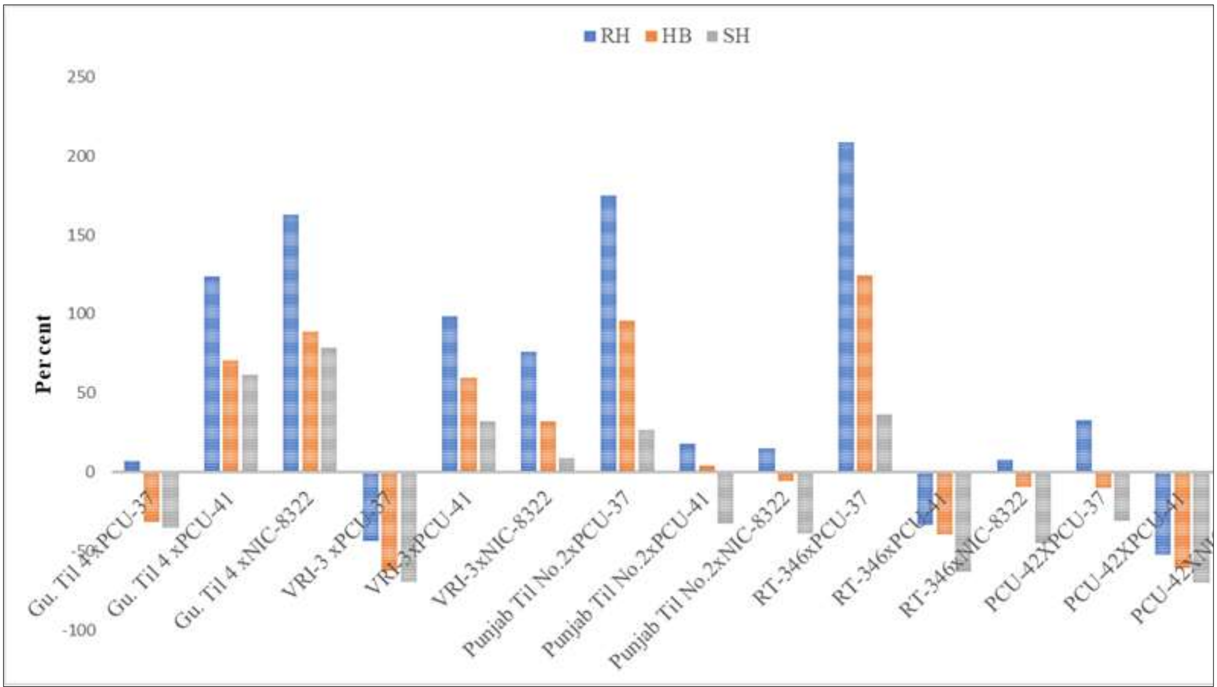

Fig 1: Estimates of heterosis for seed yield plant^{-1}

Table 4: The best performing hybrids for seed yield per plant along with heterobeltiosis, standard heterosis and *sca* effect and standard heterosis for component characters in sesame

Sl. No.	Hybrids	Relative heterosis	Heterobeltiosis	Standard heterosis	Significant desirable standard heterosis for component traits
1	Gu. Til 4 x NIC-8322	162.69	88.87	78.57	PBP, NCL, NCP, CL, NSC, TSW, DMP
2	Gu. Til 4 x PCU-41	123.52	70.71	61.41	HP, NCL, NCP, CL, NSC, DMP
3	RT-346 x PCU-37	208.71	124.24	36.25	HP, TSW, LA, DMP
4	VRI-3 x PCU-41	99.02	59.49	31.97	PBP, NCP
5	Punjab Til No.2 x PCU-37	175.24	95.99	27.04	CL, NSC, LA, DMP

HP	Height of the plant (cm)	NSC	Number of seeds capsule^{-1}
PBP	Primary branches plant^{-1}	LA	Leaf area
NCL	Number of capsules per leaf axil	DMP	Dry matter production
NCP	Number of capsules plant^{-1}	TSW	1000 seed weight (g)
CL	Capsule length (cm)		

4. Conclusion

The heterosis for seed yield plant^{-1} was also linked with heterosis for its component traits. For number of capsules plant^{-1}, four crosses depicted significant and desired standard heterosis ranged from -44.65% to 47.97%. The estimate of standard heterosis for seed yield plant-1 ranged from -69.46% to 78.57%. While heterobeltiosis for seed yield plant-1 ranged from -62.43% to 124.24%. The five hybrids viz., Gu. Til 4 x NIC-8322, Gu. Til 4 x PCU-41, RT-346 x PCU-37, VRI-3 x PCU-41 and Punjab Til No.2 x PCU-37 were identified to be the best heterotic cross combinations for the quantitative traits over the standard check. Therefore, these crosses may be further developed and used in upcoming breeding programs to enhance yield and its components in white seeded sesame.

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