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Heterosis studies for seed yield and its components in sesame (*Sesamum indicum* L.)

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Abstract
The analysis of variance revealed that significant differences among treatments, parents, hybrids and parents *v/s* hybrids for all characters except days to maturity. This validated that, considerable amount of variability among experimental material. Five crosses *viz*., TBS-10 x TBS-05, R-20 x TBS-05, TBS-07 x TBS-05, TBS-05 x R-09 and TBS-10 x V-13 manifested significant and positive heterosis over better parent and both standard checks AKT-101 and JLT-408 respectively, for seed yield per plant.
The above mentioned highly heterotic crosses also occupied top ranks in per se performance for seed yield per plant. Hence, these crosses would be exploited for isolating transgressive segregants for seed yield and its component traits for genetic improvement in sesame.

Keywords: heterosis, variability, material, positive

Introduction
Sesame (*Sesamum indicum* L.) is an ancient oil yielding crop and popularly known as "Queen of oilseeds". It domesticated well over 3000 years ago. Worldwide, it is used for its nutritional, medicinal, and industrial purposes. Sesame is commonly known as Til (Hindi/Marathi), Tai (Gujrat), Tili (Punjab), Nuvulu (telgu), Ellu (Tamil), Rasi (Orissa) besides these sesamum, gingelly, benniseed, simsim. The crop has its early origins in East Africa and India. Today, Myanmar and India is the world's largest producer of sesamum followed by China, Sudan, Uganda, Nigeria, Pakistan, Tanzania, Ethopia and Turkey.
Sesame is a short-day plant and is generally self-pollinated, while cross pollination occurs ranging from 5 to over 50 percent. It is an erect herbaceous annual plant that has two growth characteristics indeterminate and determinate, with the plants reaching heights of up to two meter most varieties show an indeterminate growth habit, which is shown as a continuous production of new leaves, flowers and capsules as long as the environment remains suitable for growth (Carlsson *et al.*, 2008) [9]. It is grown in warm regions of the tropics and sub tropics. It required annual rainfall is 500 mm and it is grown in the plain up to an elevation of 1200 m. It needs an average temperature of 25-27 ^{0}C. For quick germination, early growth, and flowering,
Sesame seed contains approximately 50 percent oil, 25 percent protein and 15 percent carbohydrates reported by (Burden 2005) [10] are used in baking, candy making and other food industries and insecticides. It is an essential component of customs beliefs, and culture. The oil has a concentration of (40%) oleic acid and (40%) linoleic acid and is used in cooking, salad dressings, and margarine. Sesame oil and food fried in sesame oil have a long shelf life because the oil contains an antioxidant called sesamol. The oil can be used to make pharmaceuticals, cosmetics, paintings, and soaps. Sesame seed are store house of energy and very rich in vitamins E, A, B complex and minerals like calcium, phosphorus, iron, copper, magnesium, zinc and potassium. It is the best substitute for mother's milk allergies. Sesame seed contains extraordinary quantities of methionine, tryptophan, and amino acids with innumerable benefits. The oil is used as the base for Ayurvedic preparations.
In Maharashtra, sesame crop covers 28.7 thousand ha, yielding 6.51 thousand tonne, and average productivity of 227 kg/ha. (Anonymous, 2022) It is mostly grown in the districts of Jalgaon, Akola, Chandrapur, Bhandhara, Dhule, Ahmadnagar and Osmanabad. An area under sesame in Maharashtra is decreasing mainly due to switch over to relatively less risk of life soybean and frequent crop failure due to drought or severe rains. Therefore, increase in sesame productivity per unit area and unit time needs intensive research in genetics and plant breeding. The current sesame types being grown have a low potential for output.

The majority of the cultivable types developed and released come from local or closely related populations with minimal management. This is the major cause attributed for low productivity potential of cultivars grown in India. This indicates the need to enhance the productivity of this crop by developing high yielding genotypes, which depend on the availability of variability for yield and its component traits in the populations. Sesame has a wide range of genetic variability in its extensive germplasm collections. However, certain highly desirable traits have not been found so far including good seed retention and resistance to certain diseases.

Heterosis is defined as the deviation of F_1 hybrid over its mid parent (Relative heterosis), better parent (Heterobeltiosis) and standard checks (Standard heterosis) as the consequence of hybridization. This evidently shows the potentiality of the crop for enhancement in yields. Commercial exploitation of heterosis is feasible only if the means of producing hybrid seeds economically could be made available. Commercial exploitation of heterosis was confined to cross pollinated group of plants with the success of hybrid rice, tomato etc. Sesame hybridization efforts are under progress.

Materials and Methods

The present study entitled "Diallel analysis for yield and yield component traits in sesame (*Sesamum indicum*. L)" was conducted, the seven diverse parents and twenty-one F_1 hybrids developed using these parents in half diallel mating design along with two control were used in an experiment to explore heterosis and combining ability in sesame. The experiment was laid in a randomized block design with two replications during *kharif* season. A total of 30 treatments, comprising 7 parents, 21 F_1`s and 2 check hybrids *viz*., AKT-101 and JLT-408 were randomly separated in each replication

A uniform piece of land was selected for laying out the experiment. The land was brought to fine tilth by ploughing and harrowing. Each treatment comprised of two rows of 4.5 m length, row spaced at 45 cm apart and with plant to plant distance 15 cm. Sowing was done by dibbling one to two seeds per hill. One plant per hill was maintained by thinning 15 days after sowing. The recommended fertilizer doses 30 kg N + 60 kg P_2O_5 + 30 kg K_2O per hectare was applied at the time of sowing and other cultural operations were followed as per schedule so as to maintain the healthy crop stand.

Table 1: List of Parental material

	Parent	Source		Parent	Source
1	TBS-10	BARC, Mumbai	5	TBS-07	BARC, Mumbai
2	TBS-05	BARC, Mumbai	6	V-29	BARC, Mumbai
3	R-09	RARS, Raichur	7	V-13	BARC, Mumbai
4	R-20	BARC, Mumbai			
Checks					
AKT-101		PDKV, Akola	JLT-408		MPKV, Jalgaon

Oservation Recorded

Five representative plants per treatment in each replication were selected randomly, tagged and observations were recorded on these plants for different characters like, Days to 50 percent flowering, Days to maturity, Plant height (cm), Number of branches per plant, Number of capsules per plant, Number of seeds per capsule, Length of capsule (cm), 1000 seed weight (g), Seed yield per plant (g), Oil content (%).

In the present investigation magnitude of heterobeltosis was observed standard heterosis for all ten characters.

The genotypes with early flowering and maturity have a special significance in multiple cropping systems. The earliest maturity hybrid *viz*., R-20 x V-13 on the basis of mean performance for the days to 50% flowering, over better parent and standard heterosis indicated correlation between per se performance and heterosis for days to 50 percent flowering. The cross, R-20 x V-13 shows that highest significant negative heterosis over better parent and both standard checks AKT-101 and JLT-408. Thus it indicated that early maturity hybrids could be developed by using parental material utilized in the present investigation.

Plant height is a significant yield determining factor. According to mean performance, the tallest hybrid TBS-10 x TBS-05 exhibited considerable positive heterosis over better parent and standard check. The number of branches per plant is an important yield attributing character. The top per se performance hybrids TBS-10 x R-05, TBS-10 x TBS-07, V-13 x R-09 recorded significant and positive heterosis over better parent and standard checks.

The number of capsules produced per plant has a direct impact on seed yield. Positive heterosis is preferred for these characteristics. TBS-10 x TBS-05, followed by R-20 x TBS-05, had the largest significant positive heterosis over better parent and standard heterosis, correlated with excellent *per se* performance. A similar result was discovered earlier that in Misra *et al*. (2008) [11] and Karande *et al*. (2018) [12], Jawaharlal *et al.* (2020) [13].

Four of the twenty-one crosses that were analysed had significant positive heterosis over standard checks and the better parent. High per se performance was shown by the R-20 x TBS-05 crosses, which showed that the number of seeds per capsule had the most significant positive heterosis over heterobeletosis and standard heterosis.

Out of 21 crosses eight, ten, crosses showed significant positive heterosis over standard checks AKT-101, JLT-408 and better parent show negatively significant for capsule length. The cross combination TBS-07 x TBS-05 exhibited the highest significant positive heterosis over better parent and both standard checks AKT-101 and JLT-408.

Eleven of the crosses under study had considerable positive heterosis over the better parent, and checks AKT-101 and JLT-408, respectively, for 1000 seed weight. The cross TBS-10 x TBS-07 showed the highest significant positive heterosis over better parent and standard heterosis, and it also ranked first for mean performance among the crosses.

Seed yield per plant is an important yield attributing characters in sesame. In present investigation six and five crosses exhibited significant positive heterobeltiosis and standard heterosis over standard checks AKT-101 and JLT-408, respectively. Five crosses *viz*., TBS-10 x TBS-05 (72.60%, 78.72% and 88.06%), R-20 x TBS-05 (50.00%, 55.32% and 63.43%), TBS-10 x V-13 (20.55%, 24.82% and 31.34%) and V-29 x R-20 (28.24%, 19.15% and 25.37%) manifested significant and positive heterosis over better parent and standard checks. It was noted that the top ranking crosses based on *per se* performance and standard heterosis were same (Table 2). Whereas ranking based on better parent heterosis and *per se* performance varied slightly. This indicated that ranking based on standard heterosis is more reliable as compared to better parent heterosis. Several workers, Saravanan *et al.* (2002) [14], Chaudhari *et al.* (2015) [3], Kumar *et al*. (2015) [15] and Jawaharlal *et al.* (2020) [13]

reported heterosis for seed yield per plant.

Crosses that demonstrated significant and positive standard heterosis for seed yield also demonstrated considerable standard heterosis in the desired direction for one or more yield contributing characteristics.

Oil has the highest quality character, with the least variance seen in the current experiment. Among the 21 crosses, the cross V-29 x R-09 had the most significant positive heterosis over the better parent and both standard checks for oil content, AKT-101 and JLT-408.

Table 2: Heterosis (%) better parent (BP), standard check (AKT-101) & (JLT-408) in 7 x 7 half diallel set of sesame

Sr. No.	Crosses	Days to 50 (%) flowering			Days to maturity			Plant height (cm)		
		1			2			3		
		BP	AKT -101 (C1)	JLT 408 (C2)	BP	AKT 101 (C1)	JLT 408 (C2)	BP	AKT 101 (C1)	JLT 408 (C2)
1	V-29 x TBS-10	-6.17 **	-14.61 **	-22.45 **	-6.08 **	-5.56 **	-3.95 *	-12.05 *	-6.81	0.20
2	V-29 x R-20	-7.41 **	-15.73 **	-23.47 **	-2.27	-4.44 **	-2.82	9.57	0.76	8.34
3	V-29 x V-13	-3.61 *	-10.11 **	-18.37 **	1.11	1.11	2.82	8.17	6.43	14.45 *
4	V-29 x TBS-07	-8.33 **	-13.48 **	-21.43 **	-2.21	-1.67	0.00	12.67	7.66	15.77 *
5	V-29 x TBS-05	-5.81 **	-8.99 **	-17.35 **	2.19	3.89 *	5.65 **	6.62	-0.95	6.51
6	V-29 x R-09	-10.1 **	-10.11 **	-18.37 **	-3.68 *	1.67	3.39 *	-3.48	2.27	9.97
7	TBS-10 x R-20	-2.47	-11.24 **	-19.39 **	-0.55	0.00	1.69	-0.18	5.77	13.73 *
8	TBS-10 x V-13	-4.82 **	-11.24 **	-19.39 **	0.00	0.56	2.26	1.96	8.04	16.17 *
9	TBS-10 x TBS-07	-1.19	-6.74 **	-15.31 **	3.87 *	4.44 **	6.21 **	10.27	16.84 **	25.64 **
10	TBS-10 x TBS-05	-4.65 **	-7.87 **	-16.33 **	3.28 *	5.00 **	6.78 **	10.71	17.31 **	26.14 **
11	TBS-10 x R-09	-4.49 **	-4.49 **	-13.27 **	0.00	5.56 **	7.34 **	0.45	6.43	14.45 *
12	R-20 x V-13	-14.4 **	-20.22 **	-27.55 **	-11.11 **	-11.11 **	-9.60 **	-6.06	7.57	-0.61
13	R-20 x TBS-07	-11.9 **	-16.85 **	-24.49 **	-5.52 **	-5.00 **	-3.39 *	11.78	6.81	14.85 *

* significance at 5 percent level and ** significance at 1 percent level

Table 2: Contd…

Sr. No.	Crosses	Days to 50 (%) flowering			Days to maturity			Plant height (cm)		
		1			2			3		
		BP	AKT -101 (C1)	JLT 408 (C2)	BP	AKT 101 (C1)	JLT 408 (C2)	BP	AKT 101 (C1)	JLT 408 (C2)
14	R-20 x TBS-05	-12.7 **	-15.73 **	-23.47 **	-4.37 **	-2.78	-1.13	16.04 *	7.81	15.92 *
15	R-20 x R-09	-13.4 **	-13.48 **	-21.43 **	-5.26 **	0.00	1.69	-6.52	-0.95	6.51
16	V-13 x TBS 07	-5.95 **	-11.24 **	-19.39 **	0.55	1.11	2.82	18.65 **	16.75 *	25.53 **
17	V-13 x TBS 05	-5.81 **	-8.99 **	-17.35 **	1.64	3.33 *	5.08 **	12.60	10.79	19.13 **
18	V-13 x R-09	-11.24 **	-11.24 **	-19.39 **	-4.21 **	1.11	2.82	6.16	12.49 *	20.96 **
19	TBS-07 x TBS-05	-5.81 **	-8.99 **	-17.35 **	-0.55	1.11	2.82	17.92 **	12.68 *	21.16 **
20	TBS-07 x R-09	-6.74 **	-6.74 **	-15.31 **	-0.53	5.00 **	6.78 **	3.13	9.27	17.50 *
21	TBS-05 x R-09	-3.37 *	-3.37 *	-12.24 **	0.53	6.11 **	7.91 **	2.14	8.23	16.38 *
	S.E. D ±	0.648	0.64	0.64	1.372	1.372	1.372	6.420	6.420	6.420
	C.D. @ 5 percent	1.330	1.330	1.330	2.816	2.816	2.816	13.17	13.17	13.17
	C.D. @ 1 percent	1.79	1.79	1.79	3.80	3.80	3.80	17.78	17.78	17.78

* significance at 5 percent level and ** significance at 1 percent level

Table 2: Contd…

Sr. No.	Crosses	No. of branches per plant			No. of capsules per plant			Capsule length (cm)		
		4			5			6		
		BP	AKT -101 (C1)	JLT -408 (C2)	BP	AKT- 101 (C1)	JLT -408 (C2)	BP	AKT -101 (C1)	JLT- 408 (C2)
1	V-29 x TBS-10	-7.41	-7.41	-10.71	-21.05 *	-25.04 *	-32.87 **	-5.41	8.95	8.32
2	V-29 x R-20	1.69	11.11	7.14	68.26 **	59.10 **	42.48 **	-3.07	10.51	9.86
3	V-29 x V-13	0.00	0.00	-3.57	7.73	-2.49	-12.67	-9.56 *	3.11	2.51
4	V-29 x TBS-07	-24.59 **	-14.81	-17.86 *	29.62 **	23.17 *	10.31	-2.56	11.09 *	10.44
5	V-29 x TBS-05	-24.24 **	-7.41	-10.71	-20.69 *	-14.77	-23.68 **	-3.34	12.45 *	11.80 *
6	V-29 x R-09	-5.56	-5.56	-8.93	23.02 *	11.35	-0.28	-1.71	12.06 *	11.41 *
7	TBS-10 x R-20	-18.64 *	-11.11	-14.29	-5.98	-10.73	-20.06 *	-4.05	10.51	9.86
8	TBS-10 x V-13	29.79 **	12.96	8.93	68.71 **	60.19 **	43.45 **	1.35	16.73 **	16.05 **
9	TBS-10 x TBS-07	31.15 **	48.15 **	42.86 **	9.00	3.58	-7.24	-0.34	14.79 **	14.12 *
10	TBS-10 x TBS-05	24.24 **	51.85 **	46.43 **	104.05 **	119.28 **	96.38 **	2.84	19.65 **	18.96 **
11	TBS-10 x R-09	26.00 **	16.67 *	12.50	12.37	6.69	-4.46	-3.72	10.89 *	10.25
12	R-20 x V-13	-11.86	-3.70	-7.14	39.97 **	32.35 **	18.52 *	-14.19 **	-3.50	-4.06
13	R-20 x TBS-07	-9.84	1.85	-1.79	43.54 **	36.39 **	22.14 *	-0.71	8.95	8.32

* significance at 5 percent level and ** significance at 1 percent level

Table 2: Contd…

Sr. No.	Crosses	No. of branches per plant			No. of capsules per plant			Capsule length (cm)		
		4			5			6		
		BP	AKT -101 (C1)	JLT -408 (C2)	BP	AKT- 101 (C1)	JLT -408 (C2)	BP	AKT -101 (C1)	JLT- 408 (C2)
14	R-20 x TBS-05	6.06	29.63 **	25.00 **	100.14 **	115.09 **	92.62 **	-2.01	14.01 *	13.35 *
15	R-20 x R-09	1.69	11.11	7.14	34.54 **	27.22 **	13.93	-5.82	7.00	6.38
16	V-13 x TBS 07	0.00	12.96	8.93	43.04 **	35.93 **	21.73 *	2.25	9.92	9.28
17	V-13 x TBS 05	-12.12	7.41	3.57	9.99	18.20	5.85	-8.70	6.23	5.61
18	V-13 x R-09	44.0 **	33.33 **	28.57 **	91.70 **	72.32 **	54.32 **	-2.05	11.28 *	10.64 *
19	TBS-07 x TBS-05	12.12	37.04 **	32.14 **	91.03 **	105.29 **	83.84 **	8.70*	26.46 **	25.73 **
20	TBS-07 x R-09	8.20	22.22 **	17.86 *	37.48 **	30.64 **	16.99 *	-6.51	6.23	5.61
21	TBS-05 x R-09	-7.58	12.96	8.93	79.45 **	92.85 **	72.70 **	-12.21 *	2.14	1.55
	S.E. D ±	0.207	0.207	0.207	2.946	2.946	2.946	0.133	0.133	0.133
	C.D. @ 5 percent	0.425	0.425	0.425	6.045	6.045	6.045	0.274	0.274	0.274

* significance at 5 percent level and ** significance at 1 percent level

Table 2: Contd…

Sr. no.	Crosses	No. Of Seed Per Capsule			1000 Seed Weight		
		7			8		
		BP	AKT -101 (C1)	JLT 408 (C2)	BP	AKT- 101 (C1)	JLT- 408 (C2)
1	V-29 x TBS-10	-3.47	9.19	4.67	3.64 **	10.74**	32.33 **
2	V-29 x R-20	-3.13	9.58	5.05	3.08*	9.48 **	30.83 **
3	V-29 x V-13	-10.2 *	1.57	-2.64	-4.35 *	4.32 *	24.67 **
4	V-29 x TBS-07	-0.83	12.18 *	7.53	-5.11 **	6.28 **	27.00 **
5	V-29 x TBS-05	-14.1**	7.93	3.46	-2.30	6.56 **	27.33 **
6	V-29 x R-09	-4.58	7.93	3.46	-4.70 **	7.53 **	28.50 **
7	TBS-10 x R-20	0.90	5.58	1.2	-4.49 **	9.76 **	31.17 **
8	TBS-10 x V-13	2.85	7.62	3.16	-11.4**	1.81	21.67 **
9	TBS-10 x TBS-07	-7.96	-3.69	-7.68	9.8**	13.81**	36.00 **
10	TBS-10 x TBS- 05	-13.1**	9.19	4.67	-5.22 **	8.93 **	30.17 **
11	TBS-10 x R-09	-4.32	7.93	3.46	-6.80 **	7.11 **	28.00 **
12	R-20 x V-13	5.33	5.58	1.20	-1.90	-6.28**	12.00 **
13	R-20 x TBS-07	-1.73	-1.96	-6.02	-10.46**	0.28	19.83 **
14	R-20 x TBS-05	-7.75	15.9 **	11.1 *	0.80*	4.18 *	24.50 **
15	R-20 x R-09	-0.56	12.18 *	7.53**	-15.82**	-5.02 *	13.50 **
16	V-13 x TBS 07	7.21	7.46	3.01	-17.19**	-7.25**	10.83 **
17	V-13 x TBS 05	-16.6**	4.79	0.45	-12.35**	-7.95**	10.00 **
18	V-13 x R-09	-4.87	7.31	2.86	-15.57**	-4.74 *	13.83 **
19	TBS-07 x TBS-05	-7.56	16.1**	11.37*	-4.11 *	7.39 **	28.33 **
20	TBS-07 x R-09	-10.31*	1.18	-3.01	-8.41 **	3.35	23.50 **
21	TBS-05 x R-09	-21.1**	-0.94	-5.05	-5.44 **	6.69 **	27.50 **
	S.E. D ±	3.135	3.135	3.135	0.065	0.065	0.065
	C.D. @ 5 percent	6.432	6.432	6.432	0.134	0.134	0.134
	C.D. @1 Percent	8.686	8.686	8.686	0.181	0.181	0.181

* significance at 5 percent level and ** significance at 1 percent level

Table 2: Contd…

Sr. No.	Crosses	Oil Content (%)			Seed Yield Per Plant		
		9			10		
		BP	AKT 101 (C-1)	JLT 408 C2	BP	AKT 101 (C-1)	JLT 408 C2
1	V-29 x TBS-10	18.61 **	26.38 **	7.93 **	-17.81	-14.89	-10.45
2	V-29 x R-20	9.77 **	19.91 **	2.4	28.24**	19.15*	25.37**
3	V-29 x V-13	-0.17	18.19 **	0.93	-16.54	-24.8**	-20.90*
4	V-29 x TBS-07	11.32 **	27.57 **	8.94 **	2.31	-5.67	-0.75
5	V-29 x TBS-05	8.32 **	28.38 **	9.63 **	-10.96	-7.8	-2.99
6	V-29 x R-09	26.99 **	35.31 **	15.55**	1.35	6.3	11.94
7	TBS-10 x R-20	-8.69 **	-0.25	-14.8**	-6.85	-3.55	1.49
8	TBS-10 x V-13	-13.98**	1.83	-13.0**	20.55*	24.82**	31.34**
9	TBS-10 x TBS-07	0.91	15.65 **	-1.24	8.22	12.06	17.91
10	TBS-10 x TBS- 05	10.04 **	30.42 **	11.38**	72.60**	78.72	88.06**
11	TBS-10 x R-09	22.04 **	28.51 **	9.75 **	0.00	4.96	10.45
12	R-20 x V-13	-6.59 **	10.58 **	-5.57 **	16.03	7.8	13.43
13	R-20 x TBS-07	-1.3	13.11 **	-3.41 **	5.34	-2.13	2.99
14	R-20 x TBS-05	-5.64 **	11.84 **	-4.49 **	50.00**	55.32**	63.43**

15	R-20 x R-09	7.01 **	16.90 **	-0.17	-24.32**	-20.57	-16.42
16	V-13 x TBS 07	6.73 **	26.34 **	7.89 **	30.7	20.57*	26.87**
17	V-13 x TBS 05	9.51 **	29.79 **	10.84 **	0.00	3.55	8.96
18	V-13 x R-09	7.23 **	26.94 **	8.41 **	-10.81	-6.38	-1.49
19	TBS-07 x TBS-05	7.28 **	27.15 **	8.59 **	38.36**	43.26**	50.75**
20	TBS-07 x R-09	-0.48	14.05 **	-2.60 *	-18.92*	-14.89	-10.45
21	TBS-05 x R-09	-0.97	17.37 **	0.23	26.35**	32.62**	39.55**
	S.E. D ±	0.536	0.536	0.536	0.574	0.574	0.574
	C.D. @ 5 Percent	1.101	1.101	1.101	1.179	1.179	1.179
	C.D. @ 1 Percent	1.487	1.487	1.487	1.592	1.592	1.592

* significance at 5 percent level and ** significance at 1 percent level

Table 3: Five best heterotic hybrids over better parents and standard check

Sr. No.	Character	Better Parent		Standard Check			
		Cross	Value (%)	(SC-1)	Value (%)	(SC-2)	Value (%)
1	Days to 50% flowering	R-20 x V-13	-14.40**	R-20 X V-13	-20.22 **	R-20 X V-13	-27.55**
		R-20 x R-09	-13.48**	R-20 X TBS-07	-16.85**	R-20 X TBS-07	-24.49**
		R-20 x TBS-05	-12.79**	R-20 X TBS-05	-15.73**	V-29 X R-20	-23.47**
		R-20 x TBS-07	-11.90**	V-29 X R-20	-15.73 **	R-20 X TBS-05	-23.47**
		V-13 x R-09	-11.24**	V-29 X TBS-10	-14.61 **	V-29 X TBS-10	-22.45**
2	Days to maturity	R-20 x V-13	-11.11**	R-20 X V-13	-11.11**	R-20 X V-13	-9.60**
		V-29 x TBS-10	-6.08**	V-29 X TBS-10	-5.56**	V-29 X TBS-10	-3.95**
		R-20 x TBS-07	-5.52**	R-20 X TBS-07	-5.00**	R-20 X TBS-07	-3.39**
		R-20 x R-09	-5.26**	V-29 X R-20	-4.49**	V-29 X R-20	-2.82**
		V-13 x R-09	-4.21**	R-20 X TBS-05	-2.75**	R-20 X TBS-05	-1.13**
3	Plant height (cm)	V-13 x TBS-07	18.65**	TBS-10 X TBS-05	17.3**	TBS-10 X TBS-05	26.14 **
		TBS-07 x TBS-05	17.92**	TBS-10 X TBS-07	16.64**	TBS-10 X TBS-07	25.64**
		R-20 x TBS-05	16.04**	V-13 X TBS-07	16.75**	V-13 X TBS-07	25.53**
		V-29 x TBS-07	12.6**	TBS-07 X TBS-05	12.68**	TBS-07 X TBS-05	21.16**
		R-20 x TBS-07	11.78 **	V-13 X R-09	12.49**	V-13 X R-09	20.96**

* significance at 5 percent level and ** significance at 1 percent level

Table 3: Contd…

Sr. No.	Character	Better Parent		Standard Check			
		Cross	Value (%)	(SC-1)	Value (%)	(SC-2)	Value (%)
4	No. of branches per plant	V-13 x R-09	44.0**	TBS-10 X TBS-05	51.85**	TBS-10 X TBS-05	46.43**
		TBS-10 x TBS-07	31.15**	TBS-10 X TBS-07	48.15**	TBS-10 X TBS-07	42.86**
		TBS-10 x V-13	29.79**	TBS-07 X TBS-05	37.04**	TBS-07 X TBS-05	32.14**
		TBS-10 x R-09	26.00**	V-13 X R-09	33.33**	V-13 X R-09	28.57**
		TBS-10 x TBS-05	24.24**	R-20 X TBS-05	29.63**	R-20 X TBS-05	25.00**
5	No. of capsules per plant	TBS-10 x TBS-05	104.0**	TBS-10 X TBS-05	119.2**	TBS-10 X TBS-05	96.36 **
		R-20 x TBS-05	100.1**	R-20 X TBS-05	115.9**	R-20 X TBS-05	92.62**
		V-13 x R-09	91.70**	TBS-07 X TBS-05	105.2**	TBS-07 X TBS-05	83.84**
		TBS-07 x TBS-05	91.03**	TBS-05 X R-09	92.85**	TBS-05 X R-09	72.70**
		TBS-05 x R-09	79.45 **	V-13 X R-09	72.32**	V-13 X R-09	54.32**
6	Capsule length (cm)	TBS-07 x TBS-05	8.70**	TBS-07 X TBS-05	24.46**	TBS-07 X TBS-05	25.73**
		TBS-10 x TBS-05	2.84**	TBS-10 X TBS-05	19.65**	TBS-10 X TBS-05	18.96**
		V-13 x TBS-07	2.25*	TBS-10 X V-13	16.73**	TBS-10 X V-13	16.05**
		R-20 x TBS-05	2.01	TBS-10 X TBS-07	14.79**	TBS-10 X TBS-07	14.12**
		TBS-10 x V-13	1.35*	R-20 X TBS-05	14.01**	R-20 X TBS-05	13.35**

* significance at 5 percent level and ** significance at 1 percent level

Table 3: Contd…

Sr. No.	Character	Better Parent		Standard Check			
		Cross	Value (%	(SC-1)	Value (%)	(SC-2)	Value (%)
7	No. of seed per capsule	V-13 x TBS-07	7.21	TBS-07 X TBS-05	16.18**	TBS-07 X TBS-05	11.37*
		R-20 x V-13	5.33	R-20 X TBS-05	15.95**	R-20 X TBS-05	11.14*
		V-13 x R-09	4.87	V-29 X TBS-05	12.18*	R-20 X R-09	7.53
		TBS-10 x V-13	2.85	R-20 X R-09	12.18*	V-29 X TBS-07	7.53
		TBS-10 x R-20	0.90	V-29 X R-20	9.58	TBS-10 X TBS-05	4.67
8	1000 seed weight	TBS-10 x TBS-07	9.8**	TBS-10X TBS-07	13.81**	TBS-10X TBS-05	36.0**
		V-29 x TBS-10	3.64*	V-29 X TBS-10	10.7**	V-29 X TBS-10	32.3**
		V-29 x R-20	3.08*	TBS-10 X R-20	9.76**	TBS-10 X R-20	31.1**
		R-20 x V-13	1.92	V-29 X R-20	9.48**	V-29 X R-20	30.8**

		R-20 x TBS-05	0.80	TBS-10 X TBS-05	8.93**	TBS-10 X TBS-05	30.1**
9	Oil content%	V-29 x R-09	26.39**	V-29 X R-09	35.31 **	V-29 X R-09	15.55**
		TBS-10 x R-09	22.04**	TBS-10 X R-05	30.42**	TBS-10X TBS-05	11.38**
		V-29 x TBS-10	18.61**	V-13 X TBS-05	29.79 **	V-13 X TBS-05	10.84**
		V-29 x TBS-07	11.32**	TBS-10 X R-09	28.51**	TBS-10 X R-09	9.73**
		TBS-10 x TBS-05	10.04**	V-29 X TBS-05	28.38**	V-29 X TBS-05	9.63**

* significance at 5 percent level and ** significance at 1 percent level

Table 3: Contd…

		Better Parent		Standard Check			
Sr. No.	**Character**	**Cross**	**Value (%)**	**(SC-1)**	**Value (%)**	**(SC-2)**	**Value (%)**
10	Seed yield per plant	TBS-10 x TBS-05	72.60**	TBS-10X TBS-05	78.72**	TBS-10X TBS-05	88.06**
		R-20 x TBS-05	50.00**	R-20 X TBS-05	55.32**	R-20 X TBS-05	63.43**
		TBS-07 x TBS-05	38.36**	TBS-07X TBS-05	43.26**	TBS-07X TBS-05	50.75**
		V-13 x TBS-07	30.77**	TBS-05 X R-09	32.46**	TBS-05 X R-09	39.55**
		V-29 x R-20	28.20**	TBS-10 X V-13	24.82**	TBS-10 X V-13	31.34**

* significance at 5 percent level and ** significance at 1 percent level

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