Combining ability studies in sesame (Sesamum indicum L.)

Shobha Rani T*., Kiran Babu T., Thippeswamy S.

Regional Agricultural Research Station, Professor Jayashankar Agricultural University,

Polasa–505 529, Telangana.

Email: *shobhamao@yahoo.co.in*

Abstract

The present study was envisaged to know the performance of hybrids developed and to characterize the parents for their combining ability for yield and yield components. The experiment was conducted with 90 hybrids with their parents (19) during summer, 2013 using two replications. The analysis of variance revealed that highly significant female x male interaction for all the traits under study. The parents, JCS 9426, JCS 96, JCS 2012(females) and TSES-POL 05, TSES-POL 02, TSES-POL 04, TSES-POL 06 (males) were found to be good general combiners for seed yield per plant. LGP 12-16 and JCS 1920 (females) and TSES-POL 02, TSES-POL 03 and TSES-POL 04(males) were found to be good general combiners for oil content. The best hybrids on the basis of sca effects were JCS 2012 x TSES-POL 09 for total number of capsules per plant, LGP 12-16 x TSES-POL 02 for 1000 seed weight, JCS 96 x TSES-POL 05 for seed yield per plant and JCS 9426 x TSES-POL 02 for seed yield per plot and JCS 2012 x TSES-POL 06 for oil content.

Keywords: Sesame, L x T design, combining ability, gca effects, sca effects.

1. INTRODUTION

Sesame is an important annual oilseed crop in the tropics and warm subtropics, where it is usually grown in small and marginal areas. Being the fourth important oil seed crop in Indian agriculture after groundnut, rape seed and mustard, it is widely cultivated in the states of Uttar Pradesh, Rajasthan, Orissa, Gujarat, Andhra Pradesh, Telangana, Tamil Nadu, Karnataka, West Bengal, Bihar and Assam.

In an often cross–pollinated crop like sesame, there is good scope for development of hybrids for oil and yield. Therefore, for breaking the present yield barrier and evolving varieties with high yield potential, it is desirable to combine the genes from genetically diverse parents. The success in identifying such parents mainly depends on combining ability and genetic makeup. Further, an understanding of the combining ability is a pre-requisite for any successful breeding programme.

Keeping all these facts in view, the present investigation was initiated to estimate combining ability effects in sesame hybrids.

2. MATERIAL AND METHODS

The present experiment was conducted at Regional Agricultural Research Station, Polasa, Jagtial, Karimnagar district, Telangana state during summer, 2014. The base material comprised of ten lines and nine testers, which were used as females and males respectively(Table 1). The lines used were JCS 96, JCS 1920, JCS 2012, JCS 2321, JCS 2432, JCS 9426, LGP 12-06, LGP 12-16, LGP 12-18, LGP 12-24 and the testers used were TSES-POL 01, TSES-POL 02, TSES-POL 03, TSES-POL 04, TSES-POL 05, TSES-POL 06, TSES-POL 07, TSES-POL 08, TSES- POL 09. Among parents, JCS 96(Swetha til) and JCS-9426(Hima) are white seeded varieties which have been developed and released by Regional Agricultural Research Station, Polasa, Jagtial during 1996 and 2006 respectively through pedigree method of breeding. The parental lines selected for the experiment were crossed manually as per the technique suggested by Thangavelu and Nallathambi (1982) to get all the 90 F1 combinations.

The experimental material consisting of 109 entries involving 19 parents and their 90 F1 hybrids was sown in Randomized Block Design with two replications during *summer*, 2014. Each replication consisting of two rows each of 109 entries. The row length was 2 m with inter and intra row spacing of 30 cm and 10 cm respectively. Observations recorded for yield and yield contributing characters, *i.e.*, total number of capsules per plant, 1000-seed weight (g), oil conten (%), seed yield per plant and seed yield per hectare. The mean of the characters for the different entries was subjected to L x T analysis and variance due to general combining ability (GCA) of parents and specific combining ability (SCA) of different cross combinations were worked out based on the procedure developed by Kempthorne (1957).

3. RESULTS AND DISCUSSION

The analysis of variance for combining ability in respect of five quantitative characters under study are presented in Table 2. The analysis of variances for combining ability indicated that, mean sum of squares due to females x males interaction were highly significant for all the quantitative traits under study. The highest significance was reported for seed yield per hectare followed by total number of capsules per plant. Where as, lowest significance for 1000 seed weight. The general combining ability (gca) and specific combining ability (sca) effect of both parents and hybrids were worked out for different characters and are presented in Table 3 and Table 4, respectively.

Total number of capsules per plant

Total number of capsules per plant is an important quantitative trait that influence the seed yield to greater extent in sesame. Of the ten lines, three lines showed significant positive gca effects. JCS 2012 (11.82), LGP 12-24 (6.67) and JCS 2321 (3.56) recorded the highest gca effects. Four lines showed significant negative gca effects *viz.*, LGP 12-06 (-10.99), JCS 2432 (-5.62), LGP 12-18 (-2.44) and JCS 96 (-1.97). Out of nine testers studied, four testers recorded significant positive gca effects out of nine testers *viz.*, TSES-POL 06 (4.79), TSES-POL 01 (4.63), TSES-POL 03 (3.86) and TSES-POL 02 (3.30). Four testers had significant negative gca effects *viz.*, TSES-POL 07 (-5.18), TSES-POL 05 (-5.11), TSES-POL 04 (-4.52) and TSES-POL 08 (-2.18). Twenty six hybrids recorded significant positive sca effects out of 36 hybrids, while 54 hybrids recorded negative sca effects of which 42 hybrids had negative significant sca effects. The sca effects for this character ranged from -21.12 (JCS 2432 x TSES-POL 06) to 54.33 (JCS 2012 x TSES-POL 09). The highest positive sca effects were recorded in JCS 2012 x TSES-POL 09(54.33) followed by JCS 96x TSES-POL 09 (27.37), LGP 12-16 x TSES-POL 03 (26.77) and LGP 12-24 x TSES-POL 05 (24.59).

Among the parents, JCS 2012, LGP 12-24, JCS 2321, TSES-POL 06, TSES-POL 01, TSES-POL 03 and TSES-POL 02 were found to be good general combiners. The highest sca effect was observed in JCS 2012 x TSES-POL 09 followed by JCS 96 x TSES-POL 06, LGP 12-16 x TSES-POL 03, LGP 12-24 x TSES-POL 05 and LGP 12-06 x TSES-POL 06. For total number of capsules per plant, both positive and negative general and specific combiners have been reported by several research workers viz ., Sajjanar (1994), Devaraj (1996), Backiyarini et al. (1997), Thakare et al. (1999), Mishra and Yadav (1996) and Kavitha et al. (1999). Ramesh et al . (1998) observed both parents and hybrids with positive gca and sca effects respectively. while Fatteh et al.(1995) recorded hybrids with both positive and negative sca effects. Das and Gupta (1999) and Ragiba and Reddy (2000) observed the parents with their general combining ability effects in both.

1000-seed weight

Seed mass is one of the important trait to have direct positive association with seed yield (Shekhara and Reddy, 1993). Among the ten lines studied, three lines recorded significant positive and another four had non-significant positive gca effects, while two lines registered negative and significant gca effect and another one line had non-significant negative gca effect. The highest positive gca effects were recorded in the line JCS 2321 (0.23) followed by JCS 1920 (0.10) and JCS 2012 (0.10). Two out of nine testers studied *viz.*, TSES-POL 02 (0.15) and TSES-POL 06 (0.10) had significant positive gca effects, while TSES-POL 09 (-0.27) and TSES-POL 03 (-0.12) had significant negative gca effects. The sca effects for 1000 seed weight ranged from -0.58 (JCS 2432 x TSES-POL 08) to 0.92 (LGP 12-16 x TSES-POL 02). Among 90 hybrids studied, 16 and 13 hybrids exhibited significant positive and negative sca effects respectively. The highest positive sca effects were recorded in LGP 12-16 x TSES-POL 02 (0.92) followed by JCS 2432 x TSES-POL 06 (0.50) and LGP 12-06 x TSES-POL 07 (0.47).

The gca effects of parents indicated that, JCS 96, JCS 1920, JCS 2012, TSES-POL 02 and TSES-POL 06 were good general combiners. High sca effects were recorded in LGP 12-16 x TSES-POL 02 followed by JCS 2432 x TSES-POL 06, LGP 12-16 x TSES-POL 01 and LGP 12-06 x TSES-POL 07. The best cross combination with LGP 12-16 x TSES-POL 02 has the parents with low and high sca effects. Parents and crosses have been identified for 1000 seed weight with general and specific combining ability effects respectively in both positive and negative direction by many workers viz., Sajjanar (1994), Devaraj (1996), Mishra and Yadav (1996), Kavitha et al. (1999) and Thakare et al. (1999), Das and Gupta (1999) and Ragiba and Reddy (2000) recorded negative gca effects of parents and positive sca effects of crosses for this trait, whereas, Ramesh et al. (1998) identified parents and crosses with positive gca and sca effects respectively. Fatteh et al. (1995) also reported hybrids with positive sca effects.

Oil content

Significant positive gca effects for oil content were observed in only one line out of six lines *viz.*, LGP 12-16 (0.39) and remaining lines are non-significant and negative gca effects were observed in four lines of which three lines had significant negative gca effects. The testers TSES-POL 03 (0.72), TSES-POL 04 (0.50) and TSES-POL 02 (0.37) exhibited significant positive gca effects, while, TSES-POL 09 (-1.04) and TSES-POL 06 (-0.37) expressed significant negative gca effects. Thirteen hybrids registered significant positive sca effects for oil content, while, fourteen hybrids exhibited significant negative sca effects. The highest positive sca effects were recorded in JCS 2012 x TSES-POL 06 (1.74) followed by LGP 12-24 x TSES-POL 01 (1.57) and LGP 12-06 x TSES-POL 09 (1.40). The sca effects for this trait ranged from -1.84 (JCS 96 x TSES-POL 06) to 1.74 (JCS 2012 x TSES-POL 06).

Among female parents, LGP 12-16 and among male parents TSES-POL 03, TSES-POL 04, TSES-POL 02 were found to be good general combiners for oil content as indicated by higher gca effects. The hybrid combination JCS 2012 x TSES-POL 06 exhibited the highest positive sca effects followed by LGP 12-24 x TSES-POL 01, LGP 12-06 x TSES-POL 06. The parents involved in the cross JCS 2012 x TSES POL 06 had low gca effects. For oil content, Sajjanar (1994), Devaraj (1996), Mishra and Yadav (1996), Backiyarini et al. (1997), Thakare et al. (1999), and Kavitha et al. (1999) recorded both positive and negative gca effects of parents and sca effects of hybrids. Whereas, Thiyagarajan and Ramanathan (1995) and Ramesh et al. (1998) reported only gca effects of parents and sca effects of crosses in positive direction. Das and Gupta (1999) recorded both positive and negative gca effects of parents and positive sca effects of hybrids.

Seed yield per plant

Significant positive gca effects for seed yield per plant were observed in three lines *viz.*, JCS 9426 (1.29), JCS 96 (0.93) and JCS 2012 (0.52). Four lines exhibited significant negative gca effects *viz.*, LGP 12-18 (-0.95), JCS 2432 (-0.57), LGP 12-24 (-0.45) and LGP 12-16 (-0.33). Out of nine testers studied, five testers exhibited positive significant gca effects and TSES-POL 05 (0.79) TSES-POL 02(0.65) and TSES-POL 04(0.64) recorded higher positive gca effects. Out of four testers studied, three testers had observed significant negative gca effect. For seed yield per plant, only 21 hybrids recorded significant positive sca effects, while other 29 hybrids registered significant negative sca effects. The highest positive sca effects were recorded in JCS 96 x TSES-POL 05 (4.00) followed by JCS 2432 x TSES-POL 07 (3.27), JCS 96 x TSES-POL 04 (3.07) and JCS 2012 x TSES-POL 02(2.07). The sca effects for this character ranged from - 2.81 (JCS 96 x TSES-POL 07) to 4.00 (JCS 96 x TSES-POL 05).

The gca effect of parents suggested that JCS 9426 (Hima), JCS 96 (Swetha til), JCS 2012 among females and TSES-POL 05, TSES-POL 02, TSES-POL 04, TSES-POL 06 among males were the best general combiners. The highest sca effects were resulted in the hybrid JCS 96 x TSES-POL 05 followed by JCS 2432 x TSES-POL 07, JCS 96 x TSES-POL 04 and JCS 2012 x TSES-POL 02. The parents involved in all these hybrids have higher gca effect. For seed yield per plant, majority of research workers reported that parents and hybrids with general and specific combining ability effects respectively in both positive and negative direction. Murthy (1975), Gupta (1981), Chaudhari et al. (1984), Sajjanar (1994), Devaraj (1996), Backiyarini et al. (1997), Thakare et al. (1999), and Kavitha et al. (1999). Anand Kumar and Sreerangaswamy (1987), Fatteh et al. (1995) and Ramesh et al. (1998) recorded positive gca and sca effects of parents and hybrids respectively, whereas, Das and Gupta (1999), Ragiba and Reddy (2000) and Manivaran and Ganesan (2001) reported positive and negative gca effects of parents and positive sca effects of hybrids. Mishra and Yadav (1996) recorded parents with positive gca effects and hybrids with both positive and negative sca effects.

Seed yield per hectare

Significant positive gca effects were observed for seed yield per hectare and four lines JCS 9426 (93.52), JCS 96 (81.79), JCS 2012 (46.910 and LGP 12-06 (39.81) recorded high positive gca effects. Three lines viz., LGP 12-16 (-55.86), LGP 12-18 (-73.77) and LGP 12-24 (-38.58) recorded the highest significant negative gca effects. Among the testers, three testers exhibited positive significant gca effect, TSES-POL 05 and TSES-POL 02 recorded higher gca effects of 89.66 and 47.44 respectively. The remaining four testers showed significant negative gca effect *viz.*, TSES-POL 09(-103.39) TSES-POL 04(-23.12), TSES-POL 08 (-17.29) and TSES-POL 01 (-10.06). Forty two hybrids had significant positive sca effects. The highest positive sca effects were recorded in the hybrid JCS 9426 x TSES-POL 02 (316.36) followed by JCS 96 x TSES- POL 06 (303.46) followed by JCS 96 x TSES-POL 02 (289.29) and JCS 2012 x TSES-POL 04(233.30). Significant negative gca effects were observed in 34 hybrids. The sca effects for seed yield per hectare ranged from - 368.65 (JCS 2012x TSES-POL 01) to 316.36 (JCS 9426 x TSES-POL 02).

Seed yield contribute the major objective in any plant breeding programme. The parents, JCS 9426, JCS 96, JCS 2012 and LGP 12-06 among females, TSES-POL 05 and TSES-POL 02 among males were found to be the good general combiners for this trait. The hybrid combination JCS 9426 x TSES-POL 02 followed by JCS 96 x TSES-POL 06, JCS 96 x TSES-POL 02 (289.29) and JCS 2012 x TSES-POL 04 (233.30) recorded the highest sca effects.

The best crosses for seed yield JCS 9426 X TSES-POL 02, JCS 96 X TSES-POL 06 and JCS 96 x TSES-POL 02 involving parents having high x high gca combinations and incidentally, the sca effects of these cross was also found to be high. Thus, it is evident that seed yielding ability of the cross is mainly due to both gca and sca effects. According to Sprague and Tatum (1942) the general combining ability is due to the additive factors and specific combining ability is due to the non-additive effects including dominance and epistasis. Hence, in these cases, high seed yielding ability of the cross is due to both additive as well as non-additive gene effects. These crosses can be recommended to be used as hybrids.

The parents, JCS 9426, JCS 96, JCS 2012 (females) and TSES-POL 05, TSES-POL 02, TSES-POL 04, TSES-POL 06 (males) were found to be good general combiners for seed yield per plant. LGP 12-16 and JCS 1920 (females) and TSES-POL 02, TSES-POL 03 and TSES-POL 04 (males) were found to be good general combiners for oil content. Therefore, these parental lines can be utilized for developing further hybrids in sesame.

The best hybrids on the basis of sca effects were JCS 2012 x TSES-POL 09 for total number of capsules per plant, LGP 12-16 x TSES-POL 02 for 1000 seed weight JCS 96 x TSES-POL 05 for seed yield per plant and JCS 9426 x TSES-POL 02 for seed yield per plot and JCS 2012 x TSES-POL 06 for oil content. Therefore, it is suggested to test these hybrids in large scale trials over locations to know their potential and stability

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Table 1. Details of Sesame genotypes used in the study along with their pedigree.

S. No	Lines	Pedigree
1	JCS 96	Swetha til released during 1996
2	JCS 1920	Advanced breeding line from AICRP on Oilseeds, Polasa
3	JCS 2012	Advanced breeding line from AICRP on Oilseeds, Polasa
4	JCS 2321	Advanced breeding line from AICRP on Oilseeds, Polasa
5	JCS 2432	Advanced breeding line from AICRP on Oilseeds, Polasa
6	JCS 9426	Hima released during 1996
7	LGP 12-06	Local germplasm collection
8	LGP 12-16	Local germplasm collection
9	LGP 12-18	Local germplasm collection
10	LGP 12-24	Local germplasm collection

S. No	Testers	Pedigree
1	TSES-POL 01	Collection from Local germplasm
2	TSES-POL 02	Collection from Mandor
3	TSES-POL 03	Germplasm from PC Unit
4	TSES-POL 04	Collection from Jalgaom
5	TSES-POL 05	Collection from Vriddhachalam
6	TSES-POL 06	Collection from Amerelli
7	TSES-POL 07	Collection from Dharwad

8	TSES-POL 08	Collection from Lathore
9	TSES-POL 09	Collection from Local germplasm

Table 2. Mean sum of squares for combining ability in respect of five characters in sesame (*Sesamum indicum* L.)

Source of Variation	d. f.	Total number of capsules per plant	1000 seed weight	Oil content	Seed yield per plant	Seed yield per hectare
Replication	1	126.00**	0.04	0.39	1.29	2721.99**
Females	9	721.71	0.35*	1.64	8.96	108048.11**
Males	8	371.03	0.31	5.43**	10.55*	55583.13
Female x Males	72	404.93**	0.17**	1.49**	4.89*	64354.23**
Error	98	9.34	0.03	0.26	0.41	328.01

* Significant at 5% and ** Significant at 1%.

Table 3. General combining ability effects for parents in respect of five characters in sesame (*Sesamum indicum* L.)

S.No.	Entries	Total number of capsules per plant	1000 seed weight	Oil content	Seed yield per plant	Seed yield per hectare
	Lines					
1	JCS 96	-1.97**	0.02	0.06	0.93**	81.79**
2	JCS 1920	-1.17	0.10*	0.22	-0.3	-9.26*
3	JCS 2012	11.82**	0.10*	-0.52**	0.52**	46.91**
4	JCS 2321	3.56**	0.23**	0.21	-0.24	-141.36**
5	JCS 2432	-5.62**	-0.05	0.21	-0.57**	-107.41**
6	JCS 9426	-0.41	0.04	-0.36**	1.29**	93.52**

7	LGP 12-06	-10.99**	-0.13**	0.14	0.10	39.81**
8	LGP 12-16	0.53	0.02	0.39**	-0.33*	-55.86**
9	LGP 12-18	-2.44**	0.06	-0.01	-0.95**	-73.77**
10	LGP 12-24	6.67**	-0.27**	-0.33**	-0.45**	-38.58**
	CD at 5%	1.43	0.08	0.24	0.30	8.45
	CD at 1%	1.89	0.11	0.31	0.40	11.23
	Testers					
1	TSES-POL 01	4.63**	0.06	-0.19	-0.39**	-10.06*
2	TSES-POL 02	3.30**	0.15**	0.37**	0.65**	47.44**
3	TSES-POL 03	3.86**	-0.12**	0.72**	0.30*	6.88
4	TSES-POL 04	-4.52**	-0.02	0.50**	0.64**	-23.12**
5	TSES-POL 05	-5.11**	0.05	-0.03	0.79**	89.66**
6	TSES-POL 06	4.79**	0.10*	-0.37**	0.38**	-5.62
7	TSES-POL 07	-5.18**	0.00	-0.09	-0.21	15.49**
8	TSES-POL 08	-2.18**	0.05	0.13	-0.98**	-17.29**
9	TSES-POL 09	0.40	-0.27**	-1.04**	-1.17**	-103.39**
	CD at 5%	1.35	0.08	0.22	0.28	8.02
	CD at 1%	1.80	0.1	0.30	0.38	10.65

* Significant at 5% and ** Significant at 1%.

Table 4. Specific combining ability effects for hybrids in respect of ten characters in sesame (*Sesamum indicum* L.)

S. No.	Entries	Total number of capsules per plant	1000 seed weight	Oil content	Seed yield per plant	Seed yield per hectare
1	JCS 2321x TSES-POL 01	-0.63	0.03	-0.87*	0.46	-99.20**
2	JCS 2321x TSES-POL 02	0.20	-0.38**	0.12	-2.78**	-234.48**
3	JCS 2321x TSES-POL	-2.36	-0.01	0.53	-0.15	-49.47**

	03					
4	JCS 2321x TSES-POL 04	16.52**	0.08	0.20	1.23**	219.41**
5	JCS 2321x TSES-POL 05	-10.39**	-0.06	-0.17	1.59**	62.19**
6	JCS 2321x TSES-POL 06	14.71**	-0.23	-0.69	0.35	132.47**
7	JCS 2321x TSES-POL 07	-7.82**	0.01	-0.17	0.63	-238.64**
8	JCS 2321x TSES-POL 08	4.18	0.26*	0.67	-0.28	-108.64**
9	JCS 2321x TSES-POL 09	-14.40**	0.31*	0.38	-1.05*	-143.52**
10	JCS 1920 x TSES-POL 01	9.60**	-0.16	0.42	0.29	-264.63**
11	JCS 1920 x TSES-POL 02	17.92**	-0.04	-0.04	0.73	-305.46**
12	JCS 1920 x TSES-POL 03	-7.14**	-0.13	-0.04	2.05**	210.09**
13	JCS 1920 x TSES-POL 04	-5.76**	0.02	-0.02	-2.12**	165.09**
14	JCS 1920 x TSES-POL 05	-7.67**	0.10	-0.84*	-1.20**	99.54**
15	JCS 1920 x TSES-POL 06	10.43**	0.00	1.10**	-0.52	-166.29**
16	JCS 1920 x TSES-POL 07	1.40	-0.04	-1.08**	1.03*	101.48**
17	JCS 1920 x TSES-POL 08	-7.60**	0.23	-0.35	-0.58	-26.85*
18	JCS 1920 x TSES-POL 09	-11.18**	0.02	0.87*	0.32	187.04**

19	JCS 2012 x TSES-POL 01	-10.39**	-0.24*	-1.19**	0.78	-368.65**
20	JCS 2012 x TSES-POL 02	-2.07	-0.50**	-1.10**	2.07**	187.75**
21	JCS 2012 x TSES-POL 03	-8.38**	0.20	0.76*	-1.04*	231.08**
22	JCS 2012 x TSES-POL 04	-8.10**	-0.13	-0.98**	-0.77	233.30**
23	JCS 2012 x TSES-POL 05	-0.16	-0.16	0.61	-1.22**	-18.36
24	JCS 2012 x TSES-POL 06	-7.56**	0.33**	1.74**	-0.41	-192.53**
25	JCS 2012 x TSES-POL 07	-2.59	-0.13	0.86*	-1.68**	172.47**
26	JCS 2012 x TSES-POL 08	-15.09**	0.41**	-1.20**	0.64	69.14**
27	JCS 2012 x TSES-POL 09	54.33**	0.21	0.51	1.62**	-314.20**
28	JCS 2012 x TSES-POL 01	-9.66**	0.12	-0.45	-1.94**	182.59**
29	JCS 9426 x TSES-POL 02	12.62**	0.12	0.14	1.41**	316.36**
30	JCS 9426 x TSES-POL 03	-5.39*	0.06	0.04	-1.00*	-203.80**
31	JCS 9426 x TSES-POL 04	-7.52**	-0.04	0.81*	-1.57**	12.31
32	JCS 9426 x TSES-POL 05	0.22	-0.46**	-0.91*	-0.30	-119.90**
33	JCS 9426 x TSES-POL 06	1.28	-0.26*	-0.82*	-0.41	-27.41*
34	JCS 9426 x TSES-POL	10.15**	0.25*	0.55	0.42	204.26**

	07					
35	JCS 9426 x TSES-POL 08	15.24**	-0.19	0.33	1.66**	117.59**
36	JCS 9426 x TSES-POL 09	-16.93**	0.40**	0.30	1.74**	-143.52**
37	JCS 96 x TSES-POL 01	12.10**	0.24*	0.48	0.98*	77.35**
38	JCS 96 x TSES-POL 02	-2.78	0.01	0.52	-0.90*	289.29**
39	JCS 96 x TSES-POL 03	2.21	-0.40**	0.38	-1.67**	4.85
40	JCS 96 x TSES-POL 04	-0.36	-0.21	-0.15	3.07**	-362.38**
41	JCS 96 x TSES-POL 05	-14.37**	0.03	0.43	4.00**	222.07**
42	JCS 96 x TSES-POL 06	-11.67**	0.08	-1.84**	-0.72	303.46**
43	JCS 96 x TSES-POL 07	-7.30**	0.30*	-1.42**	-2.81**	-114.88**
44	JCS 96 x TSES-POL 08	-5.20*	0.11	0.87*	-0.04	-212.66**
45	JCS 96 x TSES-POL 09	27.37**	-0.15	0.73*	-1.91**	-207.10**

S. No.	Entries	Total number of capsules per plant	1000 seed weight	Oil content	Seed yield per plant	Seed yield per hectare
46	JCS 2432 x TSES-POL 01	6.80**	0.23	-0.62	-0.92*	18.7
47	JCS 2432 x TSES-POL 02	-8.13**	-0.15	0.42	0.77	33.42*
48	JCS 2432 x TSES-POL 03	-10.19**	-0.13	-0.57	-2.05**	-51.01**
49	JCS 2432 x TSES-POL 04	-6.36**	0.39**	-0.30	0.68	-12.68
50	JCS 2432 x TSES-POL 05	20.28**	0.25*	0.83*	-2.61**	10.65
51	JCS 2432 x TSES-POL 06	-21.12**	0.50**	0.56	1.58**	105.92**
52	JCS 2432 x TSES-POL 07	11.50**	-0.55**	0.88*	3.27**	-137.41**
53	JCS 2432 x TSES-POL 08	15.45**	-0.58**	-0.48	-1.05*	-115.74**
54	JCS 2432 x TSES-POL 09	-8.23**	0.04	-0.72*	0.33	148.15**
55	LGP 12-06 x TSES-POL	2.52	-0.17	-0.25	-1.71**	210.37**

	01					
56	LGP 12-06 x TSES-POL 02	-11.36**	-0.04	-0.21	-1.11*	127.87**
57	LGP 12-06 x TSES-POL 03	-2.32	0.03	0.10	2.05**	-112.13**
58	LGP 12-06 x TSES-POL 04	3.66	0.02	-0.18	-2.05**	-296.02**
59	LGP 12-06 x TSES-POL 05	-0.75	-0.07	-0.15	0.78	-22.69
60	LGP 12-06 x TSES-POL 06	23.50**	0.01	-0.62	0.74	30.93*
61	LGP 12-06 x TSES-POL 07	-9.28**	0.47**	-0.20	0.68	-198.52**
62	LGP 12-06 x TSES-POL 08	-13.73**	-0.12	0.09	0.81	14.81
63	LGP 12-06 x TSES-POL 09	7.74	-0.14	1.40**	-0.19	245.37**
64	LGP 12-16 x TSES-POL 01	-15.6**	0.46**	0.65	2.82**	123.02**
65	LGP 12-16 x TSES-POL 02	-20.57**	0.92**	0.29	-1.26**	-128.92**
66	LGP 12-16 x TSES-POL 03	26.77**	-0.44**	-1.71**	1.26**	-30.03
67	LGP 12-16 x TSES-POL 04	0.05	-0.15	-0.49	0.29	77.75**
68	LGP 12-16 x TSES-POL 05	-6.86**	0.16	0.39	-1.06*	-21.14
69	LGP 12-16 x TSES-POL 06	-5.66*	-0.16	0.68	1.77**	46.36**
70	LGP 12-16 x TSES-POL 07	19.71**	-0.29*	0.00	-1.70**	55.80**

71	LGP 12-16 x TSES-POL 08	11.81**	0.03	0.18	-1.08*	88.58**
72	LGP 12-16 x TSES-POL 09	-9.62**	-0.54**	0.00	-1.04*	-211.42**
73	LGP 12-18 x TSES-POL 01	9.77**	-0.32*	0.25	-0.66	141.24**
74	LGP 12-18 x TSES-POL 02	11.79**	0.02	-0.36	0.02	8.73
75	LGP 12-18 x TSES-POL 03	6.93**	0.43**	-0.05	0.46	-25.71*
76	LGP 12-18 x TSES-POL 04	-9.49**	0.09	0.57	-1.07*	-117.93**
77	LGP 12-18 x TSES-POL 05	-4.90*	-0.04	0.25	0.75	-94.60**
78	LGP 12-18 x TSES-POL 06	10.90**	0.44**	-0.32	-1.26**	36.79**
79	LGP 12-18 x TSES-POL 07	-13.33**	0.08	-0.50	1.25**	60.12**
80	LGP 12-18 x TSES-POL 08	4.12	0.09	0.34	-0.09	1.24
81	LGP 12-18 x TSES-POL 09	-15.81**	0.02	-0.20	0.59	-9.88
82	LGP 12-24 x TSES-POL 01	-4.49*	-0.19	1.57**	-0.10	-20.8
83	LGP 12-24 x TSES-POL 02	2.38	0.04	0.21	1.05*	43.92**
84	LGP 12-24 x TSES-POL 03	-0.13	0.39**	0.57	0.08	26.14*
85	LGP 12-24 x TSES-POL 04	17.35**	-0.07	0.54	2.31**	81.14**
86	LGP 12-24 x TSES-POL	24.59**	0.16	-0.43	-0.73	-117.75**

	05					
87	LGP 12-24 x TSES-POL 06	-14.81**	0.17	0.20	-1.12*	-269.69**
88	LGP 12-24 x TSES-POL 07	-2.44	-0.11	1.07**	-1.08*	95.31**
89	LGP 12-24 x TSES-POL 08	-9.19**	-0.23	-0.44	0.01	172.53**
90	LGP 12-24 x TSES-POL 09	-13.27**	-0.17	-3.28**	-0.40	-10.8
	CD at 5%	4.28	0.24	0.71	0.9	25.36
	CD at 1%	5.69	0.32	0.94	1.19	33.68