Heterosis for seed yield and its components in sesame under supplementary irrigation

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ABSTRACT

Experiments were carried out during autumn in 2009 at two irrigated locations (Abu Naama and Sinnar) on clay plains of central Sudan. Fourteen sesame genotypes were crossed in line x tester mating scheme and heterosis over mid parent was estimated for the seed yield and its components in 49 F_1top cross hybrids. The crosses and their parents were arranged in a randomized complete block design with three replicates. The traits measured were days to 50% flowering, days to maturity, plant height, number of branches per plant, number of capsules per plant, capsule length, 1000-seed weight and seed yield. Among the crosses evaluated across the two locations: T3 x L3 and T1 x L5 combined high heterosis for early maturity with high seed yield. This indicates that the crosses were earlier and high yielders than their parents and could be utilized to develop genotype (s) suitable for locations in central Sudan, that is, characterized by varying and low total rainfall. The top four ranking crosses for seed yield across locations were T6 x L3 (1108 kg/ha), T6 x L7 (1023 kg/ha), T1 x L5 (1022 kg/ha) and T5 x L5 (1014 kg/ha). The highest percentage of mid parent heterosis for seed yield across sites were given by T3 x L3 (52%) followed by T3 x L7 (44%), T5 x L7 (44%) and T1 x L5 (43%). These crosses can be used to develop high yielding sesame hybrids through hand emasculation and pollination for further testing in multilocations trials.

INTRODUCTION

Sesame (*Sesamum indicum* L.), a member of the family Pedaliaceae, is one of the most important oilseed crops in the Sudan. It is a good source ofedible oil for human consumption with a high nutritive value and keeping quality. Also, it is one of the main cash crops for both rain-fed sector and more recently some irrigated schemes and ranks top among the agricultural exported commodities of the Sudan.

Most of the high yielding varieties of sesame in the Sudan were developed through introduction from abroad and selection. Also, the yield of sesame landraces in Sudan has been low apparently due to genetic ceiling in the existing varieties. Therefore, it is necessary to carry out breeding programs that deal with the production of new varieties through hybridization in an attempt to incorporate both advantages of higher yield and adaptability produced by hybrids and/or synthetic varieties.

The task of identifying parents that will express maximum heterosis when crossed is a concern of plant breeders. The top cross by using line x tester analysis provides the basis for generating preliminary information for heterotic pattern among population of crosses and aids in selecting candidates for recurrent selection (Ajala, 1993).

The exploitation of hybrid vigor is one of the methods of plant breeding to develop cultivars with high yielding potential. Hence, hybrid breeding appears to be promising in achieving the yield breakthrough required in sesame as seen in other self-pollinated crops such as rice, barley, wheat and tomato. The present study was undertaken to determine the degree of heterosis in 49 F_1 top cross hybrids of sesame for seed yield and its components over two supplementary irrigation conditions. The information will be useful for identifying superior hybrid combination to be used in the development of high yielding genotypes of sesame for further testing.

MATERIALS AND METHODS

The plant material used consisted of 49 F_1 top cross hybrids generated by crossing seven lines with seven testers adopting the line x tester mating scheme. The seven sesame females used as lines were designated as: Kenana-1 (L1), Huria-10 (L2), Promo (L3), Kenana-2 (L4), Khidir (L5), Um-Shagara (L6) and Bachian (L7) while, the seven sesame males used as testers were designated as: four introduced inbred lines *viz.*, UCR-7 (T2), J-4 (T4), Local Lauhi Hata (T5), High Land (T6) and three landraces *viz.*, Radom (T1), Aprawi (T3) and Karawi (T7). Both emasculation and pollination were used to develop49 F_1 top cross hybrids. During the firstweek of July 2009, the 14 parents and 49 F_1 top cross hybrids were grown and evaluated at two irrigated locations (Abu Naama and Sinnar) on the clay plains of central Sudan. The trials were arranged in a randomized complete block design, with three replicates. The plot size was 2 rows x 3 m long with inter and intra row of 80 cm and 15 cm, respectively. The seeds were sown in holes and after two weeks seedlings were thinned to one plant/hole. Three supplementary irrigations were applied to the crop during its life cycle, and plots were kept free of weeds by hand weeding.

Data were collected for days to 50% flowering (DF), days to maturity (DM), plant height (PH), number of branches/plant (NBP), number of capsules/plant (NCP), capsule length (cm) (CL), 1000-seed weight (g) (SW) and seed yield (kg/ha) (SY). Data were analyzed using the Statistical Analysis System (SAS) computer package, and the analysis was done for each location for the eight traits and then combined. Means were separated using Duncan's Multiple Range Test (DMRT).The estimation of heterosis was computed as:

$$\text{Heterosis over mid parent (MP)} = [(F_1 - MP) \times 100]/MP$$

Where: F_1 = the mean of hybrid variety.
MP = mean of the two parents involved in the cross.

RESULTS AND DISCUSSION

The performance of the seven lines and seven testers tested for eight traits in sesame was high across the two locations. Also, among the 14 sesame parents and their 49 top cross hybrids there was a significant variation that indicated the diversity in the material tested.

Mean separation and ranking

Days to 50% flowering

Days from emergence to the time when 50% of the plants opened their flowers is an indicator of the earliness of genotypes. Mean days to 50% flowering across locations for parents scored 46 days as the general mean. Mean of parents ranged between 44 days (for both L7 and L3) and 48 days for (L1), respectively (Table 1). The mean of crosses ranged between 43 days for T3 x L4 to 49 days for T4 x L1.Crop duration in sesame is one of the major factors limiting crop growth and productivity. So, development of early maturing lines is important for cultivation of sesame particularly in the rainfed sector. Hence, the earliest crosses (43 days) were T3 xL4, T3 x L7 andT5 x L4 (Table 2).

Table 1. Mean performance of 14 parents for the measured traits in sesame at the two locations, season 2009.

Parents	DF	DM	PH	NBP	NCP	CL	SW	SY
T1	46	100	99	3	84	3.1	3.2	805
T2	45	103	117	3	68	3.1	3.5	728
T3	44	99	117	4	66	2.9	3.5	799
T4	47	103	119	4	77	3.0	3.4	829
T5	45	99	109	4	73	2.9	3.3	676
T6	46	102	119	3	75	3.6	3.4	800
T7	46	103	96	3	62	3.0	3.7	601
L1	48	109	112	3	66	2.6	3.5	763
L2	46	101	103	4	67	3.0	3.1	555
L3	47	101	114	4	68	3.2	3.2	580
L4	45	100	106	3	68	3.0	3.6	677
L5	47	102	105	4	64	3.0	3.5	719
L6	46	102	107	4	70	2.9	3.2	802
L7	44	102	87	2	55	2.9	3.4	586
Mean	46	102	108	3.4	69	3.0	3.4	709
CV%	4.1	2.6	8.6	28.6	19.6	4.9	4.9	25.1
SE±	1.09	1.53	5.62	0.53	8.39	0.08	0.09	113.47

DF= Days to 50% flowering, DM= Days to maturity, PH= Plant height. NBP = Number of branches/plant, NCP= Number of capsules per plant, CL= Capsule length, SW= 1000-seed weight and SY= Seed yield (kg/ha).

Table 2. Performance of 49 crosses and their average mid parent heterosis (MPH %) for days to 50% flowering (DF), days to maturity (DM), plant height (PHT), number of branches/plant (NBP) in sesame at the two locations, season 2009.

Traits/	DF		DM		PHT		NBP	
Crosses	Mean	MPH%	Mean	MPH%	Mean	MPH%	Mean	MPH%
T1 x L1	47	1.42	105	0.64	115	9.46	3	17.65
T1 x L2	48	4.35	102	1.49	121	19.08	3	-10.00
T1 x L3	47	0.36	102	1.82	119	11.22	3	-10.00
T1 x L4	46	1.83	101	1.33	113	10.21	3	0.00
T1 x L5	45	-3.60	100	-1.15	121	17.92	3	4.76
T1 x L6	47	2.16	99	-1.97	113	9.18	3	0.00
T1 x L7	44	-1.85	100	-0.99	104	11.94	4	46.67
T2 x L1	47	0.71	102	-3.45	119	4.07	4	29.41
T2 x L2	46	2.19	101	-0.82	116	5.14	3	0.00
T2 x L3	45	-3.23	102	-0.49	120	3.74	3	0.00
T2 x L4	46	1.11	105	3.28	113	1.04	3	-10.00
T2 x L5	45	-1.45	103	0.16	106	-5.09	3	-4.76
T2 x L6	46	-0.73	103	0.32	105	-6.37	3	-10.00
T2 x L7	45	1.86	103	0.00	108	5.37	3	33.33
T3 x L1	45	-0.73	105	1.12	113	-0.88	3	15.79
T3 x L2	45	0.00	100	-0.33	114	3.64	4	0.00
T3 x L3	44	-4.73	99	-1.33	118	2.02	3	-18.18
T3 x L4	43	-3.37	99	-0.50	112	1.05	3	-27.27
T3 x L5	46	0.74	102	1.66	126	13.51	4	-4.35
T3 x L6	45	0.74	102	1.16	111	-1.04	4	18.18
T3 x L7	43	-0.38	101	0.50	117	14.85	3	17.65
T4 x L1	49	3.50	106	0.31	119	3.18	3	15.79
T4 x L2	45	-2.14	100	-1.80	121	9.31	4	9.09
T4 x L3	46	-2.46	101	-1.47	118	1.14	3	-9.09
T4 x L4	46	0.36	103	1.65	107	-4.59	3	-9.09
T4 x L5	49	4.26	103	0.81	100	-10.12	3	-21.74
T4 x L6	48	1.42	103	0.33	108	-4.57	3	-27.27
T4 x L7	46	0.36	100	-1.95	114	10.82	3	5.88

Table 2. Continued.

Traits	DF		DM		PHT		NBP	
Crosses	Mean	MPH%	Mean	MPH%	Mean	MPH%	Mean	MPH%
T5 x L1	45	-2.51	100	-3.53	108	-1.51	3	-4.76
T5 x L2	47	3.30	100	0.84	109	3.15	3	-8.33
T5 x L3	46	-0.72	99	-0.83	107	-3.88	4	0.00
T5 x L4	43	-4.44	103	4.03	99	-7.29	4	0.00
T5 x L5	46	0.36	102	2.16	109	1.87	4	-4.00
T5 x L6	44	-2.55	100	-0.66	120	11.56	4	8.33
T5 x L7	45	0.75	105	4.64	117	18.51	3	-5.26
T6 x L1	48	1.77	106	0.32	124	8.09	3	29.41
T6 x L2	45	-1.81	104	2.46	114	3.30	4	20.00
T6 x L3	46	-2.13	103	1.47	132	13.43	3	-10.00
T6 x L4	46	0.73	101	0.66	115	1.93	3	10.00
T6 x L5	47	1.08	104	1.79	117	4.76	3	-4.76
T6 x L6	46	-0.36	101	-0.65	114	1.33	4	30.00
T6 x L7	45	-1.47	102	-0.65	118	14.70	3	20.00
T7 x L1	47	0.35	105	-1.57	114	9.79	3	15.79
T7 x L2	46	-0.36	101	-0.82	107	7.54	3	-9.09
T7 x L3	49	4.26	104	1.46	120	13.79	3	-18.18
T7 x L4	45	-1.46	101	-0.98	109	8.25	3	-27.27
T7 x L5	45	-2.51	101	-1.78	112	11.11	3	-13.04
T7 x L6	46	0.36	102	-0.97	119	17.38	4	0.00
T7 x L7	46	1.47	102	-0.97	115	25.82	4	41.18
Mean	46		102		114		3.3	
CV%	4.1		2.6		8.6		28.6	
SE±	1.09	0.98	1.53	1.33	5.6	4.94	0.53	0.44

Days to maturity

Days from emergence to time when more than 75% of the capsules reached full maturity is an index for varietal adaptation in sesame. Across locations, days to maturity for crosses ranged from 99 days for T3 x L3 to 106 days for T4 xL4. The earliest maturing crosses were T3 x L3, T3 x L4 and T5 x L3 (Table 2). Among the parents, L3 and L5 recorded the lowest days to maturity (99 days for both) while, the latest parents were L1 (109 days) followed by T2 and T7 (103 days for both).

Plant height

Plant height of sesame genotypes is always of great importance to get higher biomass and economic yield. Mean plant height for the parents varied from 87 cm for L7 to 119 cm for T4 with the general mean of 108 cm. The shortest parents were L7, T7 and T1, while the tallest parents were T4, T6 and T2 (Table 1). The mean plant height for crosses varied
from 99 cm for T5 x L4 to132 for T6 x L3. Crosses T5 x L4, T4 x L5 and T1 x L7 revealed the shortest plant height (Table 2). The results indicated that the crosses were taller than their parents and increasing plant height had a direct relationship with seed yield.

Number of branches/plant

Branching habit may compensate for low population, but is not preferable for mechanical harvesting. Across locations, the highest number of branches per plant with mean of 4 branches was produced by parents L5, L6 and L3, while the lowest number was produced by parents L7 (with a mean of 2 branches) (Table 1). CrossesT5 x L6T3 x L6 and T5 x L3 scored the highest value for this trait with a mean of 4 branches for each cross (Table 2). High number of branches/plant resulted in more capsules per unit area and hence comparable seed yield. Similar trends have been reported for determinate sesame by Uzun and Cagirgan (2006).

Number of capsules/plant

The mean number of capsules per plant for parents varied from 55 for L7 to 84 for T1 (Table 1). Among the crosses, it varied from 60 for T2 x L6 to 96 for T1 x L7 (Table 3). Parents with the highest values were T1, T4 and T6 with the means of 84, 77 and 75, respectively. L7, T7 and L5 gave the lowest values with the means of 55, 62 and 64, respectively (Table 2). Crosses T1 x L7, T1 x L5 and T5 x L6 scored the highest number of capsules per plant with credits of earliness and medium plant height could be utilized in breeding programs to develop high yielding crosses (hybrids). These results agreed with those of Sumathi *et al*. (2007), who pointed to the fact that the number of capsules per plant is an important yield component that had a direct effect on sesame seed yield.

Capsule length

Capsule length is an important selection index for seed yield. Across locations, mean of capsule length for the crosses varied from 2.9 cm for (T2x L6, T3 x L6, T4 x L1, T5 x L1, T5 x L2 and T5 x L7) to 3.3 cm for T6 x L3. Crosses with the highest values were T6 x L3 (3.3 cm), T3 x L2, T4 x L2, T6 x L1 and T6 x L5 with means of 3.2 cm for each cross (Table 3). The cross T6 x L3 exhibited high seed yield with long capsules. Therefore, it could be utilized in the hybrid sesame development programs in the future.

One thousand seed weight

Test weight or seed mass is one of the important yield attributing characters. One thousand seed weight for parents was 3.4 g and it ranged from 3.1 g for L2 to 3.7 g for T7 (Table 1). Among the crosses, the mean was 3.5 g. The best crosses which obtained the highest seed weight were T3 x L (3.8 g) followed by T2 x L4and T6 x L7 (3.7 g for both crosses) (Table 3).

Table 3. Performance of 49 crosses and their average mid parent heterosis (MPH%) for number of capsules/plant (NCP), capsule length (CL), 1000-seed weight (SW), seed yield (kg/ha**)** (SY) in sesame at the two locations, season 2009.

Traits	NCP		CL		SW		SY	
Crosses	Mean	MPH%	Mean	MPH%	Mean	MPH%	Mean	MPH%
T1 x L1	84	13.14	3.0	3.51	3.7	9.68	801	-6.18
T1 x L2	67	-11.06	3.1	0.81	3.3	2.90	632	-4.73
T1 x L3	70	-8.13	3.2	0.27	3.4	8.42	757	12.74
T1 x L4	78	3.07	3.0	-1.62	3.5	4.20	702	-11.97
T1 x L5	88	18.74	3.1	1.37	3.4	1.00	1022	43.40
T1 x L6	70	-9.33	3.0	-1.93	3.3	3.94	698	-13.64
T1 x L7	96	37.65	3.1	1.95	3.4	2.54	798	19.25
T2 x L1	84	25.06	3.0	4.68	3.6	1.65	955	32.57
T2 x L2	64	-4.43	3.0	-1.36	3.4	2.76	791	14.38
T2 x L3	79	16.38	3.1	-2.39	3.6	7.50	815	13.41
T2 x L4	68	-1.95	3.0	-3.78	3.7	5.41	800	13.24
T2 x L5	67	0.76	3.0	-2.47	3.6	2.86	761	7.53
T2 x L6	60	-13.25	2.9	-4.68	3.5	4.74	929	7.97
T2 x L7	73	17.52	3.0	-3.06	3.6	5.31	836	42.27
T3 x L1	72	9.60	3.0	7.27	3.8	7.33	762	6.03
T3 x L2	69	3.76	3.2	6.44	3.2	-2.76	733	25.38
T3 x L3	74	10.45	3.1	1.37	3.4	0.50	951	51.50
T3 x L4	73	8.69	3.0	-0.56	3.5	-0.24	783	14.62
T3 x L5	77	18.97	3.1	3.68	3.6	1.90	847	29.19
T3 x L6	75	9.80	2.9	-1.99	3.4	2.74	745	12.65
T3 x L7	76	25.82	3.1	8.36	3.6	3.86	948	43.93
T4 x L1	68	-5.12	2.9	3.59	3.7	5.29	644	-16.69
T4 x L2	77	7.16	3.2	5.82	3.2	-2.04	780	11.10
T4 x L3	80	10.55	3.1	1.36	3.3	0.76	572	-4.46
T4 x L4	67	-8.01	3.1	1.10	3.4	-2.39	877	1.11
T4 x L5	70	-0.94	3.1	4.76	3.6	5.57	792	-0.33
T4 x L6	68	-7.69	3.0	-0.85	3.3	0.51	610	-31.87
T4 x L7	88	32.16	3.0	1.99	3.4	-0.74	964	17.95

Table 3. Continued.

Traits/ Crosses	NCP		CL		SW		SY	
	Mean	MPH%	Mean	MPH%	Mean	MPH%	Mean	MPH%
T5 x L1	82	17.51	2.9	5.49	3.2	-4.90	849	24.81
T5 x L2	70	0.48	2.9	-3.66	3.0	-6.25	730	15.16
T5 x L3	88	25.30	3.0	-3.58	3.2	0.78	708	8.57
T5 x L4	75	6.60	3.0	-0.56	3.5	2.44	827	14.08
T5 x L5	78	13.87	3.0	0.28	3.4	1.73	1014	37.87
T5 x L6	85	19.35	3.0	2.01	3.4	4.15	764	1.05
T5 x L7	81	26.75	2.9	0.29	3.5	5.76	901	43.58
T6 x L1	83	18.20	3.2	2.72	3.6	5.08	839	-0.70
T6 x L2	83	16.90	3.0	-7.85	3.3	1.80	535	-36.70
T6 x L3	81	12.82	3.3	-0.74	3.4	4.10	1108	39.10
T6 x L4	75	5.58	3.1	-5.05	3.5	-0.24	731	-9.49
T6 x L5	76	9.35	3.2	-3.32	3.5	2.93	789	0.65
T6 x L6	81	14.94	3.1	-5.91	3.5	6.91	965	12.99
T6 x L7	70	7.93	3.1	-3.90	3.7	10.40	1023	9.62
T7 x L1	73	14.29	3.0	6.31	3.7	1.15	855	27.36
T7 x L2	63	-1.55	3.0	0.56	3.3	-4.65	621	1.97
T7 x L3	75	15.60	3.0	-2.17	3.3	-2.93	763	7.76
T7 x L4	66	1.53	3.0	0.28	3.6	-0.69	738	2.55
T7 x L5	74	17.68	3.0	0.00	3.5	-2.79	700	4.26
T7 x L6	72	9.82	3.1	3.39	3.3	-3.65	810	8.89
T7 x L7	89	52.41	3.1	6.29	3.5	-0.94	923	34.38
Mean	76		3.0		3.5		806	
CV%	19.6		4.9		4.9		25.1	
SE±	8.39	7.34	0.08	0.07	0.09	0.09	113.47	1.82

Seed yield (kg/ha)

Seed yield/unit area is of primary importance as a breeding objective in sesame because it affects the economic return to the sesame grower. Sesame genotypes differ in their inherent yield potential. In this study, there was a considerable amount of variability among the genotypes for this character. Across locations, the mean seed yield for parents ranged from 555 kg/ha for L2 to 829 kg/ha for T4 (Table 1), while the crosses mean ranged between 535 kg/ha for T6 x L2 to 1108 kg/ha for T6 x L3 (Table 3). The best parents which scored the highest seed yield were T4 (829 kg/ha) followed by T1 (805 kg/ha), L6 (802 kg/ha) and T6 (800 kg/ha), while the best yielder crosses (hybrids) were T6 x L3 (1108 kg/ha) followed by T6 x L7 (1023 kg/ha), T1 x L5 (1022 kg/ha) and T5 x L5 (1014 kg/ha) (Table 3). Twenty one top cross hybrids had significant higher mean seed yield than the overall mean and the rest of crosses with tester T6 as main parent in their different combinations. Khalafalla and Abdalla (1997), pointed to the fact that hybrids (crosses) produced higher seed yields than their parents due to the good performance of hybrids.

Heterosis

Most of the studied traits in sesame showed higher values of mid parent heterosis across locations (Tables 2 and 3). Also, there was a great variation in the estimates of heterosis from cross to cross in the desirable or favorable direction to undesirable direction. Similar results were reported by Thiyagu *et al*. (2007) and Senthil *et al.* (2003). However, the magnitude of heterosis through average of mid parent heterosis was adopted for traits under study as follows:

Days to 50% flowering and days to maturity

Heterosis for days to 50% flowering and days to maturity were required in negative direction. Estimate of mid parent heterosis percentage for days to 50% flowering pointed to negative heterosis in the favorable direction and ranged from- 0.36 for both (T6 x L6 and T7 x L2) to -4.73 for T3 x L3, while the negative mid parent heterosis percentage for days to maturity ranged from-0.33 for T3 x T2 to-3.53 for T5 x L1 (Table 2). Among the 49 cross hybrids, 15 crosses (hybrids) have negative mid parent heterosis for both days to flowering and maturity and indicated that the crosses were earlier in flowering and maturity than their parents. Also, similar results were reported by Bhuyan and Sama (2003) and Singh *et al*. (2005) who found negative heterosis for days to 50% flowering and maturity. However, in the Sudan, the bulk of sesame is grown extensively under rainfed sector and planting late maturing varieties is risky due to frequent dry spells and erratic distribution of rainfall in some seasons and years. Under such conditions, early maturity is an adaptive value. Hence, these crosses with negative heterosis for both days to 50% flowering (22 crosses) and days to maturity (23 crosses) would be suitable for developing early maturing sesame genotypes for specific locations.

Plant height

The mid parents heterosis for plant height ranged from -0.88% to -0.12% in the desirable direction and from 1.04% to 25.82% in the undesirable direction (Table 2). Among the F_1 top crosses, 39 hybrids had positive mid parent heterosis percentages indicating that the crosses were taller than their parents. The highest and positive heterosis among the crosses was given by T7 x L7 (25.82%) followed by T1 x L2 (19.08%), T5 x L7 (18.51%) and T1 x L5 (17.92%) (Table 2).This result agreed with those of Dixit (1976) and Mishra *et al.* (1994), who reported positive heterosis for plant height in sesame. Also, 10 crosses exhibited negative heterosis and had short plants with the possibility of breeding for dwarf plants as mentioned by Dora and Kamala (1986). So, the best cross with short plants was T4 xL5.

Number of branches/plant

Estimate of mid parents heterosis for number of branches per plant in the desirable direction ranged from 0.00% to 46.67% and from - 4.00% to -27.27 % in the opposite direction. Among the crosses, 27 crosses out of 49 F_1 top cross hybrids had positive heterosis. So, the best crosses with high and positive heterosis for this trait were T1 x L7 (46.67%), T7 x L7 (41.18%), T2 x L7 (33.33%) and T6 x L6 (30.00%) (Table 2). Deepa and Kumar (2001) reported significant and positive hetrosis for number of branches per plant in sesame.

Number of capsules/plant

The mid parent heterosis for number of capsules per plant ranged from 0.48% to 52.41% in the desirable direction and from -1.55% to -13.25% in the opposite direction (Table 3). Among the 49 F_1 top crosses, 20 crosses had positive heterosis. The highest top crosses with the high mid parent heterosis for this trait were T7 x L7 (52.41%) followed by T1 x L7 (37.65%), T4 x L7 (32.16%) and T5 x L7 (30.00%). The number of capsules per plant is an important yield component and has a direct effect on seed yield, so the cross like T5 x L7 can be rated as the best hybrid based on heterosis. This cross showed positive and high heterosis for both number of capsules (26.75%) and seed yield (43.58%). Hence, magnitude of heterosis for certain trait like effective number of capsules per plant can help in the identification of superior parents (L7) and cross combinations (T7 x L7, T1 x L7, T4 x L4 and T5 x L7) for commercial exploitation of heterosis in hybrid programs or synthetic varieties to develop new high sesame varieties based on number of capsules as a selection index for seed yield.

Capsule length

Length of capsule influences the number of seeds per capsule. The mid parent heterosis for capsules length ranged from 0.00% to 8.36 % in the desirable direction and from -0.56% to -7.85% in the opposite direction (Table 3). The highest top cross hybrids with positive heterosis were T3 x L7 (8.36%) followed by T3 x L1 (7.27%), T7 x L2 (6.44%) and T7 x L1 (6.31%). The current study showed that 28 crosses had positive mid parent heterosis percentage for this trait. These crosses could be utilized in sesame hybrid programs to develop new genotypes with effective capsules length.

One thousand seed weight

Estimate of mid parent heterosis for one thousand seed weight in desirable direction ranged from 0.50% to 10.40% and from -0.24% to -6.25% in the opposite direction. Among the crosses, 35 crosses out of 49 F_1 top cross hybrids had positive heterosis. So, the best crosses with high and positive heterosis for this trait were T6 x L7 (10.40%), T1 x L1 (9.68%), T1 x L3 (8.42%) and T2 x L3 (7.50%) (Table 3). This result agreed with Bhuyan and Sama (2003), who reported significant positive heterosis for one thousand seed weight and other traits in sesame.

Seed yield

Yield is a polygenic character which is influenced by the fluctuating environment. Also, in self-pollinated crops like sesame, there is a great difficulty in producing large quantities of hybrid seeds. So, there is an urgent need to exploit heterosis in sesame for seed yield and other yield components by making all possible crosses. Therefore, the crosses (hybrids) that combined yield potential, adaptation and seed quality with considerable high performance of other agronomic traits like earliness will make a significant contribution in increasing yield in the target environments; areas that grow sesame with rain and/ or supplementary irrigation in the central clay plains of the Sudan.

However, the present study which involved 14 genotypes for heterosis, the mid parent heterosis for seed yield averaged over the two locations ranging from 0.65% to 51.50% in the desirable direction and from -0.33% to -36.70% in the undesirable direction (Table 3). Among the 49 F_1 top crosses, 39 crosses (hybrids) had highly positive heterosis. This result indicates that most of the crosses gained a positive heterosis and higher yielding than their parents. In addition, the highest percentage of mid parent heterosis for seed yield in Abu Naama was given by crosses:
T7 x L7, T3 x L7 and T4 x L7, while in Sinnar it was given by T6 x L3, T5 x L4 and T6 x L7, respectively (data not shown). Thus, the magnitude of mid parent heterosis in the favorable direction varied from cross to cross for seed yield. This indicated that the mechanism of expression of heterosis was different for each environment. These findings were in agreement with those of Sharma and Shrikant (2006) who explained the differential behavior of various hybrids in different environments for expression of heterosis. Hence, the highest positive mid parent heterosis across two locations in the desirable direction were shown by T3 x L3 (52%) followed by T3 x L7 and T5 x L7 (44% for both crosses). These findings are in agreement with those of Senthil and Ganesan (2002) who reported positive heterosis for seed yield.

Moreover, there was a wide range of genetic variability and magnitude of mid parent heterosis for other traits involving the line L7 and /or the tester T3 in their crosses. Both crosses (hybrids) T3 x L3 and T3 L7 exhibited high positive heterosis for seed yield associated with high heterosis in the favorable direction for other traits like early flowering, plant height, number of capsules per plant, capsule length and one thousand seed weight.

CONCLUSION

Based on the results obtained in this study, it could be concluded that the magnitude of heterosis over mid parent varied from cross to cross for seed yield and its components. Such variability could be exploited in sesame breeding especially for local line L7 (Bachiana) and tester T3 (Aprawi) through pedigree or backcross or bulk methods of selection. In addition, their combination (T3 x L7) resulted in considerable mid parent heterosis (44%) for seed yield combined with other traits like earliness, plant height and number of capsules per plant. Therefore, the crosses involving the tester T3 such as T3 x L3 (Aprawi x Promo) for seed yield and earliness can be exploited in heterosis breeding programs for the development of crosses (hybrids) through hand emasculation and pollination for further testing and commercial utilization.

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قوة الهجين لإنتاج البذور ومكوناته في محصول السمسم (*Sesamum indicum* L.) تحت ظروف الري التكميلي

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الخلاصة

أجريت هذه التجارب في السودان أثناء الفصل الممطر عام 2009 في أبو نعامة و سنار باستخدام تصميم القطاعات العشوائية الكاملة بثلاث مكررات بإتباع تحليل سلالة x مختبر(line x tester analysis) والذي شمل أربعة عشر أباً، وسبعة آباء ذكور male (parents) وسبعة آباء إناث (female parents) معطية 49 هجيناً. زرعت التجارب في يوم 7 يوليو 2009 في كلا الموقعين. الصفات التي تمت دراستها شملت عدد الأيام حتى 50% إزهار، عدد الأيام حتى النضج، طول النبات، عدد الفروع في النبات، عدد الكبسولات في النبات، طول الكبسولة، وزن 1000 بذرة و إنتاجية البذور. وجد أن الهجن مبكرة في الأزهار وفترة النضج مقارنة بالآباء. الهجن T3 x L3 وT1 x L5 أظهرت قوة هجين عالية في إنتاج البذور والتبكير في الإزهار والنضج. هذه الهجن يمكن استخدامها في المناطق قليلة الأمطار. أعلى الهجن إنتاجية عبر الموقعين هي T6 x L3 (كجم/هكتار 1108) ، T6 x L7 (كجم/هكتار 1023)،T1 x L5 (كجم/هكتار 1022) ،T5 x L5(كجم/هكتار1014) و T6 x L6 (كجم/هكتار 965)). الهجن التي أظهرت أعلى قوة هجين عبر الموقعين هيT3 x L3 (52%), T3 x L7 (44%)T5 x L7, (44%) و T1 x L5 (43%). ومن خلال هذه الدراسة نوصي باستخدام هذه الهجن بعد إجراء بعض الاختبارات الخاصة بالإنتاجية في مواقع ومواسم مختلفة.