# Combining ability analysis for seed yield and its components in sesame

**Mohamed Y. Hassan[1], Abu Elhassan S. Ibrahim[2], Eltahir S. Ali[1] and Gamal A. Gamos[1]**

[1]Agricultural Research Corporation, Wad Medani, Sudan.
[2]Faculty of Agricultural Sciences, University of Gezira, Wad Medani, Sudan.

## ABSTRACT

Sesame (*Sesamum indicum* L.) experiments, were carried out in central Sudan during the rainy season of 2009 at two locations (Abu Naama and Sinnar). The hybridization plan consisted of seven male and seven female parents giving 49 crosses following line x tester arrangement. Treatments were arranged in a randomized complete block design with three replicates. The crosses and their parents were sown on the 7th of July for all the experiments at both locations. The traits measured were days to 50% flowering, days to maturity, plant height, number of capsules per plant, number of seeds per capsule, capsule length, 1000-seed weight and seed yield. Analysis of variance revealed that genetic variability was highly significant for all the characters studied at both locations and across them. Combining ability analysis showed that additive gene effects were important for inheritance of days to 50% flowering, plant height, number of capsules/plant, number of seeds per capsule, capsule length, 1000-seed weight, days to maturity and seed yield, whereas non-additive gene effects were important for number of seeds/capsule, indicating that the inheritance of this trait is due to specific combining ability (SCA). Combining ability analysis showed that parents, L7, L5, T2, T5 and T6 were good combiners for high seed yield as well as for most of the other traits measured in this study. Assessment of SCA effects for seed yield at Abu-Namma revealed that hybrid T4 x L4 had a maximum positive SCA effect and a high *per se* performance followed by T2 x L2, T5 x L5 and T6 x L3, while at Sinnar T6 x L6 had the highest positive SCA effects followed by T6 xL3, T1 x L5 and T2 x L6. However T6 x L3, T1 x L5, T4 x L2 and T2 x L1 exhibited the highest SCA effects across sites. The present study suggested hybrids T6 x L3, T1 x L5 and T4 x L2 to be tested in multi-location trials for commercial utilization, while, parents L7, L5, T2 and T6 can be used in recurrent selection.

## INTRODUCTION

In the Sudan, sesame (*Sesamum indicum* L.) is an important oil seed crop, both for local consumption and for export as well as a good component in the rotation with cereal crops particularly in the rainfed sector.

The producing areas of sesame are northern Darfur and southern Gedarif, Damazin (where the annual rainfall is 450-750 mm) and northern Kordofan with 350-500 mm annual rainfall. Annual production area is variable due to the great variability in the amount and distribution of annual rainfall and price fluctuation (Khidir, 1998).

The yield of sesame landraces in Sudan has been low apparently due to genetic ceiling in the existing varieties. It is necessary to carry out breeding programs that deal with the production of new varieties derived from crosses between inbred lines and open pollinated varieties in an attempt to incorporate both advantages of high yield and adaptability produced by hybrids and/or synthetic varieties.

In formulating programs for the production of hybrid varieties, a breeder is confronted with the choice of suitable parents for hybridization.

The promising genetic stock (lines) should be screened on the basis of their combining ability. When broad base genotypes are used as testers in several crosses, the general combining ability of lines is tested by what is called the top cross method. Line x tester analysis is an extension of this method in which several testers are used instead of only one (Kempthorne, 1957). Line x tester analysis provides information about general and specific combining abilities of parents and it is helpful in estimating various types of gene effects like covariance of full and half sibs which are used in estimating additive and non-additive genetic effects and heritability values in a narrow sense. Information on gene action and combining ability helps in the choice of suitable parents for hybridization programs for developing superior $F_1$ hybrids that exploit hybrid vigor and/ or genotypes to be used in the breeding programs.

The objectives of this study were to investigate the genetic improvement in seed yield and its related traits in hybrids derived from line x tester crosses of sesame, and to estimate the general combining ability of the parents and specific combining ability of the hybrids considered for the development of high yielding hybrids.

## MATERIALS AND METHODS

The plant material used consisted of four introduced inbred lines (UCR-7, J-4, Local Lauhi Hata and High Land designated as T2, T4, T5 and T6, respectively) and three local varieties (Radom, Aprawi and Karawi designated as T1, T3 and T7, respectively) used as testers (T), and seven Sudanese released varieties (Kenana-1, Huria-10, Promo, Kenana-2, Khidir, Um-Shagara and Bachiana desinated as L1, L2, L3, L4, L5, L6 and L7, respectively, used as lines (L). The female parents (line) were grown in four rows and two rows for the male parents (line). At flowering, hand pollination was used to develop the $F_1$s. The 49 top crosses hybrids were generated using line x tester arrangement during July 2008 at Abu Naama Research Station. The 49 top crosses hybrids together with their 14 parents were evaluated during 2009 rainy season at two environmentally different locations in Sudan (Abu Naama and Sinnar Research Stations). For the hybrids evaluation, the obtained $F_1$s and their parents were grown in a randomized complete block design, with three replicates in the two locations. The plot size was 2 x 3m long for each entry in each replication, with inter- and intra-row spacing of 80 and 15 cm, respectively.

The land was prepared using disk plowing, harrowing and then ridging. Sowing date was the 7$^{th}$ of July for all experiments at the two locations. Sowing was done by hand in small furrows along the rows (ridge). Two weeks later, the stand was thinned to 15 cm along the rows. Three supplementary irrigations were applied, and plots were kept free of weeds by hand weeding.

Measurements were taken on the following parameters: Days to 50% flowering (DF), days to maturity (DM), plant height (PHT), number of capsules/plant (NCP), number of seeds/capsule (NSC), capsule length (cm) (CL),1000-seed weight (g) (SW) and seed yield (Sy) (kg⁄ha).

The analysis of variance was carried out for the collected data using the Statistical Analysis System (SAS) computer package. The analysis was done for each season for all characters and then combined and correlation of the characters was computed. For the estimation of combining ability, data from each location were analyzed separately and across the locations to determine the general combining ability (GCA) and the specific combing ability (SCA) of each line according to Griffing method-2 (1956).

## RESULTS AND DISCUSSION

### Combining ability analysis

The mean squares of combining ability variances and ratio of general combining ability (GCA) to specific combining ability (SCA) for the measured traits at Abu Naama and Sinnar Research Stations are presented in Table 1. The ratio of GCA to SCA mean variance for days to 50% flowering, plant height, number of capsules/plant, capsule length, 1000-seed weight, days to maturity and seed yield were more than one, indicating that inheritance of these traits was due to GCA effects and was mostly controlled by the additive gene action, with great possibility of genetic improvement of these traits through selection (Table 1). These findings were in line with that of Raja and Raghinam (1996) who reported that the proportion of GCA variance was high for plant height, number of secondary branches per plant, number of capsules per plant and 1000 seed weight when compared with SCA variance, but in contradiction to the findings of Sakila *et al.* (2000) who reported non-additive gene action for seven characters studied.

Table 1. Mean squares of days to 50% flowering (DF), days to maturity (DM), plant height (PHT), number of capsules /plant (NCP), number of seeds /capsule (NSP), capsule length (CL), 1000-seed weight (SW) and seed yield (kg/ha) (SY) of sesame parents and 49 lines x tester crosses tested at Abu Naama and Sinnar, 2009.

| Source of variation | DF | DM | PHT | NCP | NSC | CL | SW | 99SY |
|---|---|---|---|---|---|---|---|---|
| Locatio | 84.30** | 428.48** | 260.69** | 739.90** | 1.79 | 499.15** | 1.66 | 233.88** |
| Lin | 1.73 | 3.44* | 4.46* | 1.59 | 4.13** | 14.05** | 8.73** | 0.87 |
| Teste | 3.65** | 6.97** | 4.20** | 0.46 | 68.33** | 12.85** | 4.74** | 1.42 |
| Line x locatio | 0.74 | 0.15 | 1.16 | 1.49 | 1.75 | 0.91 | 2.10* | 0.35 |
| Tester x locatio | 1.89 | 2.07* | 4.00** | 1.15 | 2.15** | 2.52* | 2.13* | 1.25 |
| Line x teste | 2.66** | 5.06** | 4.72** | 1.13 | 31.95** | 14.47** | 5.90** | 1.21 |
| Line x tester x locatio | 1.29 | 1.02 | 2.61** | 1.24 | 1.98** | 1.42 | 2.24* | 0.79 |
| Pooled errc | 1.09 | 1.53 | 5.62 | 8.39 | 2.02 | 0.09 | 0.10 | 113.47 |
| GC/ | 0.48 | 1.69 | 18.59 | 10.59 | 0.48 | 0.00 | 0.00 | 3.78 |
| SC/ | 0.12 | 0.11 | 1.12 | 2.12 | 0.45 | 0.00 | 0.00 | 0.20 |
| GCA/SC/ | 4.14 | 15.80 | 16.59 | 4.99 | 0.98 | 3.13 | 2.11 | 18.97 |

*,** Significantly different at 0.05 and 0.01 levels of probability, respectively.

The ratio was less than one for number of seeds/capsule, indicating that the inheritance of this trait was due to the non-additive gene action. It revealed that dominance and epistasis played major roles in the inheritance of this character. It also revealed the possibility of hybrid breeding for this character. Solanki and Gupta (2001) reported that the relative estimates of variance due to SCA were higher than those for GCA for all the characters except days to maturity and plant height, indicating the predominance of non-additive gene action, however, similar findings were reported by Geeta and Subramanian (1992).

The present study showed the importance of additive gene action for all the characters studied except for number of seeds/capsule as shown by the high ratio of GCA: SCA at Abu Naama, Sinnar, as well as the combined analysis (Table 1).

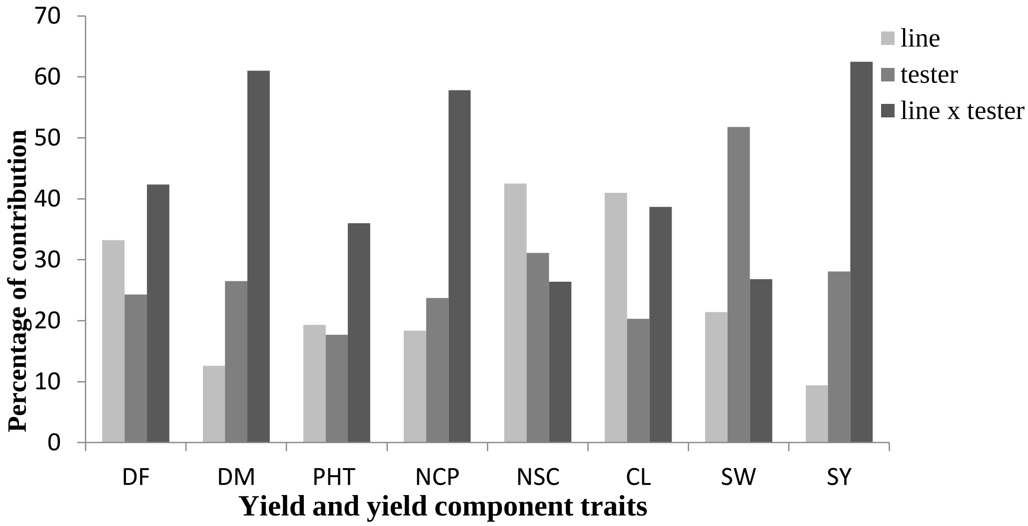
The variation in the estimates of GCA effects for the measured traits in the two locations were large and hence the estimates of GCA effects for the combined analysis of the two locations were presented in (Table 2). Parents that gave negative estimates of GCA effects for time to 50% flowering manifested earliness. T3 was the best combiner for earliness followed by L4, L7 and T5. This significant negative GCA can be considered a desirable trait in future breeding programs, since it can contribute to earlier maturity, indicating their potential to produce early maturing hybrids. Therefore, these parents could be utilized in the development of early flowering genotypes that suited the rainfed sector which is characterized by varying and low total rainfall, while parents that contributed to lateness were L1 and T4, since they gave the highest positive significant estimates of GCA effects (Table 2).

Table 2. GCA effects of days to 50% flowering (DF), days to maturity (DM), plant height (PHT), number of capsules /plant (NCP), number of seeds/capsule (NSC), capsule length (CL), 1000-seed weight (SW) and seed yield (kg/ha) (SY) for parents in sesame across locations, season 2009.

| Parents | DF | DM | PHT | NCP | NSC | CL | SW | SY |
|---|---|---|---|---|---|---|---|---|
| T1 | 0.47** | -0.61* | 1.01 | 3.24* | -0.57* | 0.03* | -0.04* | -1.59** |
| T2 | -0.15 | 0.73* | -1.76* | -5.10** | -1.42** | -0.05** | 0.13** | 1.00* |
| T3 | -1.44* | -0.94** | 1.77* | -1.91 | -0.80* | 0.01 | 0.05* | 0.26 |
| T4 | 1.18** | 0.25 | -1.61* | -1.67 | 0.05 | 0.02* | -0.04* | -0.30 |
| T5 | -0.72** | -0.51* | -4.14** | 4.33** | -1.99** | -0.11** | -0.13** | 0.63* |
| T6 | 0.18 | 1.01** | 5.25** | 3.19* | 2.53** | 0.11** | 0.04* | 0.53* |
| T7 | 0.47** | 0.06 | -0.52 | -2.10* | 2.20** | -0.01 | -0.01 | -0.54* |
| L1 | 1.18** | 2.20** | 2.10* | 2.48* | -1.80** | -0.06** | 0.15** | -0.00 |
| L2 | 0.23 | -0.89** | 0.44 | -5.00** | 1.91** | 0.03* | -0.22** | -2.72** |
| L3 | 0.14 | -0.61* | 4.96** | 2.52* | 1.39** | 0.07** | -0.08** | 0.22 |
| L4 | -0.96** | -0.18 | -4.28** | -3.91* | -1.42** | 0.00 | 0.08** | -0.40 |
| L5 | 0.14 | 0.16 | -1.28 | 0.00 | -0.57* | 0.02* | 0.06** | 1.62** |
| L6 | 0.18 | -0.56* | -1.14 | -2.33** | -0.76* | -0.06** | -0.07** | -0.53* |
| L7 | -0.91** | -0.13 | -0.80 | 6.24** | 1.25** | 0.00 | 0.07** | 1.82** |
| S.E± | 0.29 | 0.39 | 1.42 | 2.06 | 0.47 | 0.02 | 0.03 | 0.51 |

*, ** Significant at 0.05 and 0.01 levels of probability, respectively.

The contribution of general and specific combining ability for these traits differed from location to another, so that, in combined analysis, the great contribution was given by specific combining ability (42.36%) compared with the general combining ability (33.2%) for line and (24.3%) for tester, respectively (Fig. 1). T1 x L5, T4 x L2 and T1 x L7 exhibited negative and significant SCA for days to 50% flowering and positive and significant SCA for number of capsules/plant. These crosses could be exploited for developing and isolating high yielding genotypes, combined with early maturity. From these results, the hybrids had great contribution than their parents. This confirmed that this trait was controlled by non-additive gene action. Babu *et al.* (2004) reported the importance of both additive and non additive type of gene action for days to 50% flowering in sesame, whereas Vidhyavathi *et al.* (2005) reported the importance of non-additive type of gene action for this trait.




DF = Days to 50% flowering, DM= days to maturity, PHT = plant height, NCP= number of capsules/plant, NSP= number of seeds/capsule, CL= capsule length, SW= 1000-seed weight and SY = seed yield (kg/ha).

Fig. 1. Parent contribution of the sesame GCA and SCA to the total variance across locations, season 2009.

Maturity has direct influence on seed yield and total biomass production. For this trait, GCA variance was more than SCA variance suggesting that days to maturity was largely under the control of additive gene action. Therefore, it is advisable to utilize suitable parents having negative GCA effects to obtain early maturing hybrids. Across locations, parents T3, L2, L3 and T1 had negative significant GCA values of -0.94, --0.89, -0.61 and -0.61, respectively. While the positive significant GCA effects was obtained by L1, T5 and T2 (Table 2). Crosses T5 x L7, T7 x L3 and T2 x L4 showed highly positive significant SCA effects (Table 3). The great contribution for this trait was given by specific combining ability (61%) compared with the general combining ability (12.6%) for lines and (26.5%) for testers (Fig. 1).

Across locations, parents L4, T5, T2 and T4 gave highly significant negative GCA effects for plant height with values of -4.28, -4.14, -1.76 and -1.61, respectively, indicating that these lines had desirable alleles for reduced plant height. Parents T6, L3 and L1 had the highest positive GCA effects for this trait (Table 2). Regarding specific combining ability, four crosses T4 x L5, T1 x L7, T5 x L3 and T7 x L2 showed negative and significant SCA effects. T5 x L6, T3 x L5, T4 x L2 and T6 x L3 gave the highest SCA effects (Table 3). The largest contribution obtained by SCA (63%) for crosses but lower in GCA of contribution (19.3%) for lines and (17.7%) for testers (Fig.1). The predominance of SCA effects suggested that variation among crosses was mainly due to non-additive rather than additive effects of genes.

Table 3. SCA effects of days to 50% flowering (DF), days to maturity (DM), plant height number of capsules /plant (NCP), number of seeds/capsule (NSC), capsule length (CL), (PHT), 100-seed weight (SW), seed yield (kg/ha) (SY) for crosses in sesame across locations, season 2009.

| Parents | DF | DM | PHT | NCP | NSC | CL | SW | SY |
|---|---|---|---|---|---|---|---|---|
| T1 x L1 | 0.01 | 1.56* | -1.72 | 3.24 | 0.04 | -0.04 | 0.12 | -1.34* |
| T1 x L2 | 1.29* | 1.32* | 4.95* | -6.95* | -0.67 | 0.02 | 0.05 | -0.27 |
| T1 x L3 | 0.39 | 1.70* | -1.2 | 11.81* | 0.25 | 0.03 | 0.10* | -0.01 |
| T1 x L4 | 0.82* | -0.06 | 2.33 | 3.29 | -2.01* | -0.01 | 0.02 | -1.41* |
| T1 x L5 | -1.95** | -1.73* | 6.66* | 8.71* | 1.47* | 0.02 | -0.11* | 5.35** |
| T1 x L6 | 0.67 | -1.68* | -1.15 | -6.95* | -0.67 | -0.02 | -0.05 | -1.20 |
| T1 x L7 | -1.23* | -1.11* | -9.82** | 10.48** | 1.33* | 0.00 | -0.12* | -1.13 |
| T2 x L1 | -0.04 | -2.44** | 4.71* | 10.91** | 1.23* | 0.07* | -0.14** | 2.87** |
| T2 x L2 | 0.58 | -0.68 | 3.04 | -0.95 | 0.18 | 0.03 | 0.05 | 0.35 |
| T2 x L3 | -0.99* | -0.30 | 2.85 | 6.19* | 1.04 | 0.02 | 0.09* | 1.96* |
| T2 x L4 | 0.77* | 2.27** | 4.76* | 0.29 | -0.48 | 0.00 | 0.07* | 0.68 |
| T2 x L5 | -0.66 | 0.06 | -5.58* | -3.95 | -2.01* | -0.02 | -0.04 | -2.55** |
| T2 x L6 | -0.37 | 0.99* | -6.05* | -8.29* | -0.48 | -0.03 | -0.01 | 0.36 |
| T2 x L7 | 0.72* | 0.22 | -3.72* | -4.19 | 0.52 | -0.07* | -0.02 | 0.23 |
| T3 x L1 | -0.09 | 1.89* | -4.82* | -3.95 | 0.61 | -0.02 | 0.14** | -2.31* |
| T3 x L2 | 0.20 | -0.68 | -2.48 | 0.19 | 0.90 | 0.10* | -0.05 | 0.83 |
| T3 x L3 | -1.04* | -1.63* | -3.01 | -2.33 | -1.25* | -0.02 | -0.07* | 2.30* |
| T3 x L4 | -0.61 | -2.06** | 0.90 | 3.10 | -1.41* | -0.06* | -0.05 | -0.04 |
| T3 x L5 | 0.96* | 0.94 | 11.23** | 3.52 | 1.71** | 0.00 | 0.01 | -0.11 |
| T3 x L6 | 0.25 | 1.32 | -3.91* | 3.19 | -1.10* | -0.10* | 0.01 | 0.25 |
| T3 x L7 | 0.34 | 0.22 | 2.09 | -3.71 | 0.57 | 0.10* | 0.01 | -0.91 |
| T4 x L1 | 0.96* | 1.70* | 4.23* | -8.52* | -0.91 | -0.10* | 0.09* | -1.94* |
| T4 x L2 | -1.76** | -1.54* | 8.23** | 8.29* | 0.37 | 0.11* | 0.01 | 3.81** |
| T4 x L3 | -0.99** | -1.16* | 0.37 | 3.76 | 0.23 | 0.00 | -0.03 | -1.10 |
| T4 x L4 | 0.10 | 0.75 | -1.05 | -3.14 | -0.29 | 0.02 | -0.09* | 2.32* |
| T4 x L5 | 1.67** | 0.75 | -10.72 | -4.05 | 0.52 | 0.06* | 0.16** | -0.20 |
| T4 x L6 | 0.29 | 1.13* | -3.53* | -3.71 | 1.04 | -0.04 | -0.04 | -3.63** |
| T4 x L7 | -0.28 | -1.63* | 2.47 | 7.38* | -0.96 | -0.05 | -0.11* | 0.75 |

Table 3. Continued.

| Parents | DF | DM | PHT | NCP | NSC | CL | SW | SY |
|---|---|---|---|---|---|---|---|---|
| T5x L1 | -1.14* | -3.54** | -3.58* | -0.86 | -1.35* | 0.03 | -0.24** | 0.76 |
| T5 x L2 | 1.48** | -0.11 | -1.25 | -4.71 | -0.25 | -0.10* | -0.11* | -0.28 |
| T5 x L3 | 0.58 | -1.73* | -7.77** | 5.76* | -3.39** | -0.07* | -0.01 | -3.38** |
| T5x L4 | -1.33* | 1.84* | -6.20* | -0.81 | 1.42* | 0.04 | 0.09* | 0.09 |
| T5 x L5 | 0.58 | 0.84 | 0.14 | -2.05 | 0.57 | 0.00 | 0.05 | 1.55* |
| T5 x L6 | -0.80* | -1.11* | 11.66** | 7.62* | 0.76 | 0.12** | 0.10* | -0.39 |
| T5 x L7 | 0.63 | 3.80** | 6.99** | -4.95 | 2.42** | -0.03 | 0.12* | 1.65* |
| T6 x L1 | 0.63 | 0.61 | 3.04 | 1.95 | 0.95 | 0.07* | -0.03 | -0.52 |
| T6 x L2 | -1.09* | 1.70* | -5.29* | 9.10* | 0.57 | -0.13** | 0.02 | -4.29* |
| T6 x L3 | -0.33 | 0.75 | 7.85** | -0.76 | 0.76 | 0.13** | -0.03 | 6.42** |
| T6 x L4 | 0.77* | -1.35* | -0.58 | 0.67 | 0.23 | 0.00 | -0.13* | -1.70* |
| T6 x L5 | 0.67 | 0.65 | -0.91 | -2.91 | -0.63 | 0.00 | -0.04 | -1.90* |
| T6 x L6 | -0.04 | -0.97* | -3.72* | 6.76* | 0.90 | -0.02 | 0.06 | 2.47* |
| T6 x L7 | -0.61 | -1.40* | -0.39 | -14.81** | -2.77** | -0.05 | 0.15** | -0.49 |
| T7 x L1 | -0.33 | 0.22 | -1.86 | -2.76 | -0.39 | -0.01 | 0.06 | 2.48** |
| T7 x L2 | -0.71* | -0.01 | -7.20** | -4.95 | -1.10* | -0.03 | 0.02 | -0.15 |
| T7 x L3 | 2.39** | 2.37** | 0.95 | -0.81 | 2.09* | -0.09* | -0.05 | -2.28* |
| T7 x L4 | -0.52 | -1.40* | -0.15 | -3.38 | 2.57 | 0.01 | 0.08* | 0.07 |
| T7 x L5 | -1.28* | -1.40* | -0.82 | 0.71 | -1.63** | -0.06* | -0.02 | -2.15* |
| T7 x L6 | 0.01 | 0.32 | 6.71* | 1.38 | -0.44 | 0.10* | -0.07* | 2.14* |
| T7 x L7 | 0.44 | -0.11 | 2.37 | 9.81* | -1.10 | 0.09* | -0.02 | -0.10 |
| SE± | 0.71 | 0.95 | 3.48 | 5.05 | 1.14 | 0.06 | 0.07 | 1.24 |

*, ** Significant at 0.05 and 0.01 levels of probability, respectively.

Number of capsules/plant is an important yield component that has direct effects on seed yield (Sumathi *et al*.,2007). Parents having negative significant GCA effects were T2, L2, L4 and L6, whereas, L7, T5, T1 and T6 had positive significant GCA effects (Table 2). However, among the crosses T4 x L1, T2 x L6, T1 x L2 and T1 x L6 showed negative significant SCA effects. T1 x L3, T2 x L1, T1 x L7 and T7 x L7 exhibited the highest significant SCA effects (Table 3). Out of 12 F1 hybrids showing significant and positive SCA effects for number of capsules/plant, 11 hybrids involved one of the parents having high GCA effect for number of capsules/plant while the other parent had low GCA effect for this trait. This indicated that diversity in parental GCA effects played an important role in the production

of hybrids with significant positive SCA effects for number of capsules/plant in sesame. Reddy and Arunachalam (1981) reported that diversity in parental GCA effects was necessary for the development of specific combinations with high value. In combined analysis, the greatest contribution was given by specific combining ability (57.8%) compared with the general combining ability (18.4%) for lines and (23.7%) for testers (Fig. 1).

Across locations, the best combiner for number of seeds/capsule were T6, T7, L2 and L3 with values of 2.53, 2.20, 1.91 and 1.39, respectively, while parents T5, L1, L4 and T2 showed negative and significant GCA effects (Table 2 ). Crosses with the positive SCA effects were T7 x

L4, T5 x L7 and T7 x L3 (Table 3). The greatest average contribution in combined analysis was obtained by GCA (42.5%) for lines compared with GCA (31.1%) for testers and (26.4%) for SCA (Fig. 1).

Across locations, parents having positive GCA effects for capsule length were T6, L3, L2 and T1. Parents T5, L1 and L6 showed the highest negative significant GCA values (Table 2). Crosses with the negative SCA effects were T5 x L7, T4 x L1 and T5 x L2, while crosses T6 x L3, T5 x L6 and T4 x L2 showed highly positive significant SCA effects (Table 3). The highest contribution for this trait was given by GCA (41%) for lines compared with GCA (20.3%) for testers and (38.7%) for SCA (Fig. 1).

Crosses showing positive significant GCA effects for1000-seed weight were L1, T2, L4 and L7. Negative significant GCA effects were given by L2, T5 and L3 (Table 2). The best crosses having positive and significant SCA effects were T4 x L5, T6 x L7, T3 x L1 and T5 x L7. Negative SCA effects were exhibited by T5 x L1, T2 x L1 and T6 x L4 (Table 3). ). In the combined analysis, the GCA contribution was higher (51.8%) compared with 21.4 % for lines and 26.8% for crosses (Fig. 1). The present investigation indicated that the character, 1000-seed weight had a fixable additive genetic variance which could be improved by simple selection. Similar results were reported by Yamanura and Nadaf (2008).

Across locations, parents with the highest positive significant GCA effects for seed yield were L7, L5, T2, T5 and T6 with values of 1.82, 1.62, 1.00, 0.63 and 0.53, respectively. Parents L2, T1, T7 and L6 exhibited negative significant GCA effects (Table 2). With regard to SCA, T6 x L2, T5 x L3 and T4 x L6 showed negative SCA effects. The hybrid T4 x L4 had the highest positive SCA effects for seed yield followed by T2 x L2, T5 x L5 and T6 x L3 at Abu-Namma. With regard to performance *per se* for crosses, it was noticed that these crosses ranked 6$^{th}$, 9$^{th}$, 2$^{nd}$ and 1$^{st}$, respectively, whereas at Sinnar hybrids topcross T6 x L6, T6 x L3, T1 x L5 and T2 x L6 showed the highest positive SCA effects. However, in combined analysis, hybrid T6 x L3 followed by T1 x L5, T4 x L2 and T2 x L1 showed the highest positive SCAvalues (Table 3). Parents T6, L5, T2 and L3 involved in these crosses exhibited positive GCA values. The high SCA value for these crosses along with positive GCA values from its inbred lines, showed that these crosses were the highest yielding in this set.

The crosses T6 x L3 and T1 x L5 were the best crosses for seed yield at Abu-Namma (1231, 1156 kg/ha) Sinnar (985, 889 kg/ha) as well as in combined analysis (1108, 1022 kg/ha), ).4respectively (Table

Table 4. Mean performance of crosses for sesame seed yield at Abu Naama, Sinnar and across locations season 2009.

| Crosses | Abu Naama | Sinnar | Combined | Crosses | Abu Naama | Sinnar | Combined |
|---|---|---|---|---|---|---|---|
| T1 x L1 | 896 | 706 | 801 | T4 x L5 | 903 | 681 | 792 |
| T1 x L2 | 801 | 464 | 632 | T4 x L6 | 832 | 388 | 610 |
| T1 x L3 | 928 | 587 | 757 | T4 x L7 | 1167 | 762 | 964 |
| T1 x L4 | 945 | 459 | 702 | T5x L1 | 1010 | 688 | 849 |
| T1 x L5 | 1156 | 889 | 1022 | T5 x L2 | 835 | 626 | 730 |
| T1 x L6 | 899 | 497 | 698 | T5 x L3 | 889 | 518 | 708 |
| T1 x L7 | 1078 | 518 | 798 | T5x L4 | 779 | 874 | 827 |
| T2 x L1 | 1197 | 714 | 955 | T5 x L5 | 1218 | 811 | 1014 |
| T2 x L2 | 1110 | 471 | 791 | T5 x L6 | 1052 | 475 | 764 |
| T2 x L3 | 1009 | 620 | 815 | T5 x L7 | 1031 | 771 | 901 |
| T2 x L4 | 1005 | 594 | 800 | T6 x L1 | 1051 | 626 | 839 |
| T2 x L5 | 913 | 609 | 761 | T6 x L2 | 777 | 293 | 535 |
| T2 x L6 | 994 | 913 | 929 | T6 x L3 | 1231 | 985 | 1108 |
| T2 x L7 | 850 | 822 | 836 | T6 x L4 | 975 | 487 | 731 |
| T3 x L1 | 931 | 592 | 762 | T6 x L5 | 1108 | 470 | 789 |
| T3 x L2 | 754 | 712 | 733 | T6 x L6 | 917 | 1013 | 965 |
| T3 x L3 | 991 | 912 | 951 | T6 x L7 | 1078 | 968 | 1023 |
| T3 x L4 | 790 | 776 | 783 | T7 x L1 | 1057 | 653 | 855 |
| T3 x L5 | 907 | 786 | 847 | T7 x L2 | 874 | 367 | 621 |
| T3 x L6 | 1055 | 435 | 745 | T7 x L3 | 1035 | 491 | 763 |
| T3 x L7 | 1170 | 726 | 948 | T7 x L4 | 870 | 607 | 738 |
| T4 x L1 | 867 | 420 | 644 | T7 x L5 | 837 | 564 | 700 |
| T4 x L2 | 905 | 655 | 780 | T7 x L6 | 945 | 674 | 810 |
| T4 x L3 | 1062 | 415 | 572 | T7 x L7 | 1151 | 696 | 923 |
| T4 x L4 | 1161 | 593 | 877 | | | | |
| Mean | | | | | 980 | 640 | 806 |
| S.E± | | | | | 102.31 | 115.77 | 113.47 |

The crosses T6 x L3, T1 x L5 and T2 x L1 having significant and positive SCA effects for seed yield, involved parents with high GCA effects for seed yield. Superiority of such hybrids might be due to additive and additive x additive type of interaction, which is fixable (Singh *et al*. (1971). Therefore, high yielding genotypes could be obtained in the segregating generations of these crosses. Chakraborti and Basu (2000) emphasized the importance of both additive and non-additive gene action for the inheritance of yield and other important yield contributing characters in sesame.

Mishra *et al*. (1994) reported a non-additive type of gene action for seed yield. The results of this study showed that parents L7, L5, T2, T5 and T6 were the best general combiners for seed yield through their high GCA effects. Such parents could be utilized in recurrent selection to incorporate their desirable traits. The crosses T6 x L3 and T1 x L5 were found as potential combinations for number of capsules per plant, number of seed/capsule, capsule length along with yield and other traits. Accordingly, these hybrids could be recommended for future testing in multilocation trials to confirm their high yield consistency before release for commercial utilization. In the combined analysis, SCA contribution was (62.)5%, while GCA contributed (9.4%) for lines and (28.1%) for testers (Fig. 1).

**Traits association**

The coefficient of rank correlations of general combining ability between agronomic traits of sesame parents across the two locations were presented in Table 5. Seed yield was positively significantly correlated with 1000-seed weight and positively correlated with the number of capsules/plant and days to maturity. These results were in agreement with those of Kinninson (1978) who reported positive and significant correlations of seed yield with total number of capsules/plant and 1000-seed weight. Seed yield was negatively correlated with days to 50% flowering, plant height, number of seeds/capsule and capsule length. These results disagreed with those of Sharaan and Ghallab (1997) who reported a positive correlation of seed yield with branches/plant and plant height. Number of capsules/plant was positively correlated with plant height, days to maturity and number of seeds/capsule. Similar results were reported by Osman and Khidir (1974) who found that number of capsules/plant, plant height, height to first capsule and total number of seeds/plant were positively correlated with seed yield. Days to 50% flowering showed a positive and significant correlation with days to maturity. Number of capsules/plant and 1000 seed weight were significantly and negatively correlated. Plant height was positively and significantly correlated with number of seeds/capsule and capsule length and negatively correlated with seed yield. Similar results were reported by Ong'injo and Ayiechol (2009).

Table 5. Coefficient of rank correlations for various traits based on ranking GCA effects for sesame parental populations and lines across locations, season 2009.

| Trait | DF | DM | PHT | NCP | NSC | CL | SW | SY |
|---|---|---|---|---|---|---|---|---|
| DF | | 0.50 | 0.27 | -0.01 | 0.17 | 0.08 | -0.09 | -0.33 |
| DM | | | 0.19 | 0.15 | -0.13 | -0.09 | 0.67 | 0.32 |
| PHT | | | | 0.31 | 0.45* | 0.67** | 0.02 | -0.07 |
| NCP | | | | | 0.09 | 0.13 | 0.07 | 0.42 |
| NSC | | | | | | 0.73** | 0.23 | -0.18 |
| CL | | | | | | | -0.05 | -0.08 |
| SW | | | | | | | | 0.61* |
| SY | | | | | | | | |

DF = days to 50% flowering, DM = days to maturity, PHT = plant height, NCP= number of capsules /plant, NCS = number of seeds/capsule, CL = capsule length, SW = 1000-seed weight and SY = seed yield (kg/ha).
*,** Significantly different at 0.05 and 0.01 levels of probability, respectively.

## CONCLUSION

In conclusion, the study suggested that the parents Karawi, Khidir, UCE-7, Local Lauhi Hata and High Land were the best general combiners for seed yield and could, therefore, be utilized in recurrent selection to incorporate their desirable traits. The parents T3, L4, L7 and T5 were good combiners for earliness. Therefore, these parents could be utilized in the development of early flowering genotypes that suited the rainfed sector which is characterized by varying and low total rainfall. Three of the best crosses, namely, T6 x L3, T1 x L5 and T4 x L2 were found as potential combinations for number of capsules per plant, 1000-seed weight along with yield and other traits. Accordingly, these hybrids could be recommended for future testing in multilocation trials to confirm their high yield consistency before release for commercial utilization.

## REFERENCES


Babu, D.R., P.V.R. Kumar, C.V.D. Rani and A.V. Reddy. 2004. Studies on combining ability for yield and yield components in sesame (*Sesamum indicum* L.). Journal of Oil Seeds Research 21:260–262.

Chakraborti, P. and A.K. Basu. 2000. Combining ability analysis of oil content and fatty acid components in sesame under alluvial and saline conditions. Crop Research 19: 505-511.

Geeta,S. and M. Subramanian. 1992. Analysis of combining ability effect in Sesamum. Crop Research 5 (3): 586-589.

Griffing, B. 1956. Concept of general and specific combining ability in relation to diallel crossing system. Australian Journal of Biological Sciences 9: 463-493.

Kempthorne, O. 1957. An Introduction to Genetic Statistics. John Wiley, New York, USA.

Khidir, M.O. 1998. Oil Seed Crops in the Sudan. Khartoum University Press, Sudan(in Arabic).

Kinninson, N.S. 1978. Heterosis for yield and yield components in sesame (*Sesamum indicum* L.). University of California, Riverside, M.S. Thesis, 213 p.

Mishra, A.K., L.N. Yadav, R.K.S. Tomar and I.S. Raghu. 1994. Heterosis and combining ability in genetically diverse lines in sesame. Sesame and Safflower Newsletter 9: 21-29.

Onginjo, E.O. and P.O. Ayiecho. 2009. Genotypic variability in sesame mutant lines in Kenya. African Crop Science Journal 17(2): 101-107.

Osman, H.E. and M.O. Khidir. 1974. Estimation of genetic and environmental variability in sesame. Experimental Agriculture 10: 105-112.

Raja, R.G. and A.A.D. Raghinam. 1996. Combining ability analysis in sesame. Sesame and Safflower Newsletter 11: 70-75.

Reddy, B.B. and V. Arunachalam. 1981. Evaluation of heterosis through combining ability in pearl millet. I. Single crosses. Indian Journal of Genetics 41: 59-65.

Sakila, M., S.M. Ibrahim, A. Kalamani and S. Backiyarani. 2000. Correlation studies in sesame (*Sesamum indicum* L.). Sesame and Safflower Newsletter 15: 26-28.

Sharaan, A.N. and K.H. Ghallab. 1997. Character association at different locations in sesame. Sesame and Safflower Newsletter 12: 66-75.

Singh, T.H., S.P. Gupta and P.S. Phul. 1971. Line x tester analysis of combining ability in cotton. Indian Journal of Genetics 31: 316-321.

Solanki, Z.S. and D. Gupta. 2001. Combining ability and heterosis studies for seed yield and its components in sesame (*Sesamum indicum* L.). Sesame and Safflower Newsletter 16: 9-12.

Vidhyavathi, R., N. Manivannan and V. Muralidharan. 2005. Line x tester analysis in sesame (*Sesamum indicum* L.). Indian Journal of Agricultural Research 39:225–228.

Sumathi, V., V. Muralidharan and N. Manivannan. 2007. Trait association and path coefficient analysis for yield and its attributing traits in sesame (*Sesamum indicum* L.). Madras Agricultural Journal 94:174-178.

Yamanura, K.M. and H.L. Nadaf. 2008. Combining ability and gene action for yield and yield components in sesame (*Sesamum indicum* L.). Karnataka Journal of Agricultural Science 22 (2): 255-260.

# المقدرة على التآلف لإنتاج البذور ومكوناته فى محصول السمسم
(*Sesamum indicum* L. )

**محمد يوسف حسن عباس[1] وأبو الحسن صالح إبراهيم[2] والطاهر صديق على[1] و جمال ادم جاموس[1]**
[1]هيئة البحوث الزراعية واد مدنى، السودان.
[2]كلية العلوم الزراعية، جامعة الجزيرة واد مدنى، السودان.

## الخلاصة

أجريت هذه التجارب في السودان أثناء الفصل الممطر عام 2009 في أبو نعامة وسنار بإتباع تحليل سلالة x مختبر line x tester analysis) والذي شمل سبعة آباء ذكور(male parents) وسبعة أباء اناث (female parents) معطية 49 هجيناً. أستخدم تصميم القطاعات العشوائية الكاملة بثلاث مكررات. 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 الكبسولات في النبات، عدد البذور في الكبسولة، طول الكبسولة، وزن 1000 بذرة وإنتاجية البذور. أظهر تحليل التباين وجود فروق معنوية لكل الصفات المدروسة في الموقعين. أظهر تحليل القدرة علي التالف أن تأثيرات الفعل الإضافي للجين كانت أهم لتوريث صفات عدد الأيام حتى 50% إزهار، طول النبات، ارتفاع أول كبسولة، ارتفاع أول فرع، عدد الفروع في النبات، عدد الكبسولات في النبات، طول الكبسولة، عدد الأيام حتى النضج، وزن 1000 بذرة و إنتاجية البذور كما كانت تأثيرات الفعل الجيني غير الإضافي مهمة في توريث صفة عدد البذور في الكبسولة وهذه النتيجة تشير بان السيادة وتفاعلات التفوق تتحكم في تلك الصفة. أظهرت تأثيرات القدرة العامة للاتحاد إن الآباء T5, T2, L5, L7 و T6 كانت الأفضل قدرة على الاتحاد لإنتاج البذور بالإضافة لأغلب الصفات الأخرى في التحليل المشترك. الهجن التي أظهرت أعلى قوة هجين في أبونعامة T5 x L5, T2 x L2, T4 x L4 وT6 x L3، بينما في سنار T6 x L6, T6 x L3, T2 x L6 وT1 x L5 وعبر الموقعين T4xL2, T1 x L5, T6 x L3, و T2 x L1. وجد أن هناك ارتباطاً موجباً لإنتاجية البذور لكل من وزن 1000 بذرة ، عدد الكبسولات في النبات وعدد الأيام حتى النضج. اقترحت الدراسة الحالية إن الهجن T1 x L5, T6 x L3 وT6 x L7 لإنتاج البذور أما الآباء T4، T1، L6 و T6 فيمكن استخدامهم في التهجين الرجعى.