



## Combining Ability Analysis for Grain Yield and Some Agronomic Traits in Maize (*Zea mays* L.) Inbred Lines Throughout, Diallel Mating Design at Kassala State, Sudan

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### ABSTRACT

This study was conducted to analyze the combining ability for yield and some agronomic traits of maize inbred lines at two locations, Tacroof, Kassala Research Station farm and Sawagi in a farmer field, at Kassala state, Sudan Five parental line (TZBRD-ADQ-2, TZBRD-ADQ-3, TZBRD-ADQ-4, TZBRD-AD-5 and TZBRD-COMP-6) and their ten single cross (F1 hybrid) (TZBRD-ADQ-2× TZBRD-ADQ-3, TZBRD-ADQ-2× TZBRD-ADQ-4, TZBRD-ADQ-2× TZBRD-AD-5, TZBRD-ADQ-2× TZBRD-COMP-6, TZBRD-ADQ-3× TZBRD-ADQ-4, TZBRD-ADQ-3 ×TZBRD-AD-5, TZBRD-ADQ-3× TZBRD-COMP-6, TZBRD-ADQ-4× TZBRD-AD-5, TZBRD-ADQ-4× TZBRD-COMP-6 and TZBRD-AD-5× TZBRD-COMP-6) of maize developed by using Diallel mating design. Four experiments were conducted in two consecutive summer seasons 2016 and 2017. The studied traits included

days to 50% tasseling, days to 50% silking, plant height (cm), ear height (cm), ear length (cm), ear diameter (cm), number of rows per ear, number of kernel per row, 100 kernel weight (g), and grain yield (ton/ha). Out of the five parents considered as the best combiner at Kassala site, such as parent **TZBRD-COMP-6**, **TZBRD-ADQ-3** and **TZBRD-ADQ-4**, which showed a highly significant general combining ability effects in desirable direction for all studied traits. Therefore, these lines could be utilized in improvement of the respective traits in any breeding programs where hybridization was involved. Regarding to, Sawagi location, the best combiner were the parents **TZBRD-ADQ-3**, **TZBRD-COMP-6**, and **TZBRD-ADQ-2** recorded highly significant general combining ability effects in desirable direction for 50% tasseling, days to 50% silking, ear length, ear diameter, 100 kernels weight, number of row per ear, number of kernel per row and grain yield. Among the ten cross combinations, the best cross was, **TZBRD-ADQ-2**× **TZBRD-ADQ-3** recorded significant SCA effect in the desirable direction for all traits except days to 50% silking, plant height and number of kernel per row at Kassala location, but at Sawagi location cross **TZBRD-ADQ-3**×**TZBRD-COMP-6** recorded significant SCA effect in the desirable direction for days to 50% tasseling, days to 50% silking, plant height and number of kernel per row, followed by cross **TZBRD-ADQ-2**×**TZBRD-ADQ-3** which recorded a significant SCA effect in the desirable direction for ear height, ear length and grain yield.

**Keywords:** *Maize; Combining Ability; Diallel Mating; Kassala.*

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## 1. INTRODUCTION

Maize (*Zea mays L.*) is one of the most important cereals both for human and animal consumption. Successful cultivation markedly depends on the right choice of varieties. Griffing (1956) proposed a more general procedure for diallel analysis, which makes provision for non-allelic interaction.

According to this approach, mean measurement of a cross is partitioned into major components, apart from the general mean ( $\mu$ ) and environmental variance.

General combining ability (GCA) is used to designate the average performance/ contribution of the parents/line in hybrid combination (Sprague and Tatum, 1942). Falconer and Mackay (1996) defined it as the mean performance of the line in all crosses, when expressed as a deviation from the mean of all crosses. GCA consists of additive and additive epistatic variances (Matzinger, 1963; Singh, 1993; Li *et al.*, 1995).

Specific combining ability (SCA) is used to designate those cases in which certain combinations do relatively better or worse than would be expected on the bases of the average performance of the line involved (Sprague and Tatum, 1942). It is the deviation to a greater or lesser extent from the sum of the GCA of its two parents. SCA consists of dominance and all types of epistatic variances are regarded as an estimate of effects on non-additive gene actions (Cruz and Vencovsky, 1989; Falconer and Mackay, 1996; Viana, 2000).

Variety selection trails to identify the best suitable varieties for given areas frequently necessary. Genetic improvement in traits of economic importance along with maintaining sufficient amount of variability is always the desired objective in maize breeding programs. Hallauer and Scobs, (1972) observed considerable genotypic variability among various maize genotypes for different traits. Ihsan *et al.* (2005) also reported a significant genetic difference for morphological parameters for maize genotypes; this variability is a key to crop improvement.

Diallel crossing programs have been applied to achieve this goal by providing a systematic approach for the detection of suitable parents and crosses for the investigated characters. In addition, Diallel analysis gives plant breeders the opportunity to choose the most efficient selection method by allowing them to estimate several genetic parameters (Verhalen and Murray, 1967). GCA and SCA effects help locate parents and crosses that

are responsible for bringing about a particular type of gene action (Baker, 1978; Meredith, 1984). GCA and SCA effects and variances are effective genetic parameters of direct utility to decide the next phase of the breeding program (Arunachalam, 1976; Dabholkar, 1992). It helps selection of parents for construction of synthetics, selection of suitable F1s for a multiple crossing or composite breeding program and the possibility of employing an appropriate selection technique like modified mass selection, recurrent selection and reciprocal selection (Dabholkar, 1992). However, the objective of this study was to estimate general combining ability of the parental lines of maize and specific combining ability of their hybrids considered for the development of high yielding hybrids.

## 2. MATERIALS AND METHODS

The studied materials were evaluated in two seasons 2016/017 and 2017/018, respectively, at two different locations, Tacroof and Sawagi in Kassala Research Station., Sudan. Tacroof is located at latitude 14° 24' N, longitude 33° 29' E and 496 meter above sea level. The soil is classified as Ustertic Camborthids (Malawiya soil series); it is none calcareous, none sodic and none saline with thin granular surface mulch and slightly cracking (UNDP Sudan Government, 1973). Also described as a high calcareous soil, with a pH of 8.1 and low organic matter content (0.047%). The Sawagi is located at latitude 14° 24' N, longitude 33° 29' E, and annual rainfall of 400 mm, the soil was characterized by-loamy soil pH of 7.6, 505meter above sea level.

Plant materials which were used in this study contained five in bred lines as the parents (TZBRD-ADQ-2, TZBRD-ADQ-3, TZBRD-ADQ-4, TZBRD-AD-5 and TZBRD-COMP-6) then crossed in Diallel arrangement to obtain ten single cross F1 hybrids (TZBRD-ADQ-2× TZBRD-ADQ-3, TZBRD-ADQ-2× TZBRD-ADQ-4, TZBRD-ADQ-2× TZBRD-AD-5, TZBRD-ADQ-2× TZBRD-COMP-6, TZBRD-ADQ-3× TZBRD-ADQ-4, TZBRD-ADQ-3 ×TZBRD-AD-5, TZBRD-ADQ-3× TZBRD-COMP-6, TZBRD-ADQ-4× TZBRD-AD-5, TZBRD-ADQ-4× TZBRD-COMP-6 and TZBRD-AD-5× TZBRD-COMP-6).

For the estimation of combining ability, data from each site was analyzed separately and across the two sites to determine the general combining ability (GCA) and the specific combining ability (SCA) of each line was measured according to Griffing's method 2 (1956).

Combining ability analysis for F1 hybrids and their parents was based on the procedures developed by Griffing's (1956), in the combining ability analysis, the data was rearranged by pooling the observations from the four replications and finally taking their mean, thus each genotype will be represented by only one observation.

The experiments were arranged in a Randomized Complete Block Design (RCBD), with three replicates in the two sites. The plot size was maintained in 2 rows 5 m long for each entry in each replication, with inter and intra row spacing of 80 and 20 cm, respectively. Land was prepared using disk plowing, harrowing and then ridging. Sowing date was the first week of August for all experiments at the two sites. Seeds were sown at the rate of 3- 4 seeds per hill. The plants were later thinned to one plant per hill three weeks after sowing and plots were kept free of weeds by hand weeding, adding fertilizer, without pesticide and watering every seven days.

From five randomly selected plants of each plot were used for data collection, field germination percentage, plant stand, days to 50% tasseling, days to 50% silking, plant height (cm), ear height (cm), ear length (cm), ear diameter (cm), cob diameter (cm), number of rows/ear, number of kernel/row, 100 kernels weight (g) and grain yield (ton/ha) were measured in this study.

### **3. RESULTS AND DISCUSSION**

#### **Days to 50% Tasseling**

At Tacroof site, out of five parents exhibited highly significant GCA effect in negative direction and are considered as good combiners for earliness for days to 50% tasseling in desirable direction such as. **TZBRD-**

**ADQ-3 and TZBRD-COMP-6**, but **TZBRD-ADQ-2** and **TZBRD-ADQ-4** showed a positively significant GCA effect as a latest parent (Table 1). The best earliness crosses were **TZBRD-ADQ-2**× **TZBRD-ADQ-3** and **TZBRD-ADQ-3**×**TZBRD-AD-5** showed negative significance in the desirable direction for the earliness (Table 2). These results indicated that, the crosses having highly specific combining ability in desirable direction, are superior and possible recommended for selection in hybridization programs for earliness.

At the second site (Sawagi) parents **TZBRD-ADQ-2** and **TZBRD-ADQ-3** showed a high negatively significant GCA effect in the desirable direction recorded as the earliness parents. The best crosses there showed highly significant SCA effect in a positive direction such as, **TZBRD-ADQ-3**×**TZBRD-AD-5**, **TZBRD-ADQ-3**×**TZBRD-COMP-6** and **TZBRD-ADQ-3**×**TZBRD-ADQ-4** can be considered as earliness crosses. Whereas, the late cross showed significant and positively SCA effects were **TZBRD-ADQ-2**×**TZBRD-ADQ-3**, (Tables 3 and 4). Similar results were presented by Suneetha *et al.* (2000), Desai and Singh (2001), Amiruzzaman *et al.* (2013) and Rajitha (2013). These results also confirm the involvement of both additive and non-additive gene actions in the inheritance of this character. Similar results were also reported by Suneetha *et al.* (2000), Desai and Singh (2001), Amiruzzaman *et al.* (2013) and Rajitha (2013). The additive component of gene action of this trait can be improved by breeding methods involving simple selection like mass selection, ear-to-row method, etc and non-additive component can be exploited by heterosis breeding methods.

### **Days to 50% Silking**

At Tacroof site, parental lines, **TZBRD-ADQ-3**, **TZBRD-AD-5** and **TZBRD-COMP-6** exhibited high significant and negatively GCA effect are considered as good combiners for days to 50% silking in desirable direction (Table 1). The **TZBRD-ADQ-2** and **TZBRD-ADQ-4** showed

positive significant GCA. The cross **TZBRD-ADQ-2 × TZBRD-ADQ-3**, **TZBRD-ADQ-2×TZBRD-ADQ-4**, **TZBRD-ADQ-3×TZBRD-AD-5**, **TZBRD-ADQ-4×TZBRD-AD-5** (-0.02) and **TZBRD-AD-5×TZBRD-COMP-6** showed negatively significant SCA effect and considered as the best crosses, (Table 2). Whereas, at Sawagi site, the parent **TZBRD-ADQ-3** shown highly significant and negatively GCA effects, but **TZBRD-AD-5**, showed non-significant general combining ability effect (Table 3). In contrast, the crosses **TZBRD-ADQ-3×TZBRD-AD-5** and **TZBRD-ADQ-3×TZBRD-COMP-6** showed negatively and significant SCA effect in desirable direction (Table 4). These results in line with Desai and Singh (2001), Singh and Jamwal (2004), Amiruzzaman *et al.* (2013) and Rajitha (2013). The involvement of both gene actions was earlier indicated by Geetha and Jayaraman (2000), Desai and Singh (2001), Singh and Jamwal (2004), Amiruzzaman *et al.* (2013) and Rajitha (2013). For improvement of this trait, breeding programmes like population improvement as well as heterosis breeding can be employed for exploitation of both the gene actions.

### **Plant Height (cm)**

Out of five parents, at Tacroof , **TZBRD-ADQ-4**, **TZBRD-AD-5** and **TZBRD-COMP-6** showed high significant with positive GCA effect (Table 1) , while **TZBRD-ADQ-2** and **TZBRD-ADQ-3** showed high significant with negative GCA effect and considered as the shortest parents, the shortness cross (F1hybrids), **TZBRD-ADQ-2×TZBRD-ADQ-4** and **TZBRD-ADQ-3×TZBRD-COMP-6**, showed high negatively and significant SCA effect in appositive direction (Table 2). Whereas, **TZBRD-ADQ-2×TZBRD-AD-5**, **TZBRD -ADQ-3 ×TZBRD-AD-5**,**TZBRD-ADQ-4×TZBRD-AD-5** and **TZBRD-AD-5×TZBRD-COMP-6** showed positively and highly significant SCA effect. These results indicated that, the crosses with high specific combining ability in desirable direction resulted from the parents having high GCA effects.

At Sawagi site, **TZBRD-ADQ-3** showed high negative and significant general combining ability effect, **TZBRD-AD-5** having a high significant negative GCA effect (Table 3). The Cross **TZBRD-ADQ-3**×**TZBRD-ADQ-4**, **TZBRD-ADQ-3**×**TZBRD-ADQ-5** and **TZBRDADQ3**×**TZBRD-COMP-6** obtained a high significant SCA effect in negative direction. These findings were in disagreement with finding of Geetha and Jayaraman (2000), Suneetha *et al.* (2000), Desai and Singh (2001), Gautam (2003), Katna *et al.* (2005) and Amiruzzaman *et al.* (2013).

#### **Ear Height (cm)**

At Tacroof site, the best combiner parent **TZBRD-ADQ-2** showed high significant and negative GCA effect (Table 1), but **TZBRD-ADQ-4** and **TZBRD-AD-5** showed high significant with positive GCA effect. Among hybrids the only one cross record high significant with positive direction SCA effect was **TZBRD-ADQ-3** ×**TZBRD-AD-5**. Whereas, Crosses (F<sub>1</sub> hybrids) **TZBRD-ADQ-2**×**TZBRD-ADQ-3**, **TZBRD-ADQ2**×**TZBRD-ADQ-4**, **TZBRD-ADQ-2**×**TZBRD-COMP-6** and **TZBRD-ADQ-4**×**TZBRD-COMP-6** showed negatively with highly significant SCA effect (Table2). However, these results indicated that, the best crosses in desirable direction resulted from the parents having high GCA effects.

At Sawagi site, **TZBRD-ADQ-3** showed high positive significant general combine ability effect, but parent **TZBRD-AD-5** obtained a high significant but in negative direction, while, parents **TZBRD-ADQ-4** and **TZBRD-COMP-6** recorded positive direction but was not significant in general combining ability effect (Table 3). The Cross **TZBRD-ADQ-3**×**TZBRD-AD-5**, obtained high significant with positive direction, **TZBRD-ADQ-2**×**TZBRD-ADQ-3**,**TZBRD-ADQ-2**×**TZBRD-AD-5** 1.17, **TZBRD-ADQ-3**×**TZBRD-ADQ-4** and **TZBRD-ADQ-3**×**TZBRD-COMP-6** showed positive direction in SCA effect, but was not significant (Table 4). These results indicated that, cross with high specific combining ability in un-desirable direction resulted from the female parent having high GCA and male parent having

low GCA effects. These results disagree with El-Baroudiy (1999) and Malik *et al*, (2004).

### Ear Length (cm)

At Tacroof site, parental lines, TZBRD-ADQ-4 and TZBRD-COMP-6 recorded highly significant and positive general combining ability effects in desirable direction, while line TZBRD-ADQ-2 and TZBRD-AD-5 having a high significant GCA effect in negative direction and TZBRD-ADQ-3 positive direction without significance (Table1). The cross combination TZBRD-ADQ-2×TZBRD-AD-5 and TZBRD-ADQ-3×TZBRD-AD-5 showed highest significant effect for specific combine ability in the desirable direction. Whereas TZBRD-ADQ-2×TZBRD-COMP-6, TZBRD-ADQ-3×TZBRD-ADQ-4, TZBRD-ADQ-4×TZBRD-AD-5 and TZBRD-AD-5×TZBRD-COMP-6 showed an effect in the desirable direction for SCA but not significant (Table 2). These results indicated that, crosses with high specific combining ability in desirable direction are derived from parents having high GCA effects. The superiority of the crosses having low GCA parent may be due to high mating ability of those parents. Thus, in practice, some of the low combiners can also be included in heterosis breeding program.

At the second site, among five parents, TZBRD-ADQ-2 and TZBRD-ADQ-3 recorded high significant positive general combining ability effects. TZBRD-ADQ-4 and TZBRD-AD-5 having a significant GCA effect in negative direction, whereas, TZBRD-COMP-6 showed an effect in the desirable direction for GCA but not significant (Table 3). The cross (F<sub>1</sub> hybrid) TZBRD-ADQ-2×TZBRD-ADQ-3 showed highly and positively significant SCA effect, while, cross TZBRD-ADQ-3×TZBRD-ADQ-4 having high significant in negative direction SCA effect. Whereas, TZBRD-AD-5×TZBRD-COMP-6 recorded non-significant in desirable direction (Table 4). These results indicated that crosses with high specific combining ability in desirable direction are from parents having high GCA effects.

These findings were in agreement with the results of Kalla *et al.* (2001), Gautam (2003), Katna *et al.* (2005) and Khan *et al.* (2014).

### Ear Diameter

At Tacroof site, parents **TZBRD-ADQ-4**, **TZBRD-AD-5** and **TZBRD-COMP-6**, showed positively significant effect for GCA as the best combiner, but **TZBRD-ADQ-2** and **TZBRD-ADQ-3** recorded high significant with negative direction for GCA effect (Table 1). The cross **TZBRD-ADQ-2** × **TZBRD-ADQ-3** and **TZBRD-ADQ-2** × **TZBRD-COMP6**, was significant in a positive direction, while **TZBRD-ADQ-2** × **TZBRD-ADQ-4**, showed positive direction with no significant SCA effect (Table 2).

At the Sawagi site, among five parents, only parent **TZBRD-ADQ-3** obtained positively and high significant for general combine ability effect, as good combiner for ear diameter but parent **TZBRD-ADQ-2** in positive direction but no significant GCA effect (Table3). The only cross ( $F_1$  hybrid) record desirable direction with no significant for SCA effect was **TZBRD-ADQ-3** × **TZBRD-AD-5** (Table 4).

Rodrigues and Chaves (2002) and Lone (2006) obtained similar results for Ear diameter.

### Number of Rows/Ear

At Tacroof, out of five parents, **TZBRD-ADQ-4** and **TZBRD-COMP-6** exhibited significant GCA effect for number of rows per ear in desirable direction as the best combiner, while **TZBRD-AD-5** having positive direction without significance; whereas **TZBRD-ADQ-2** and **TZBRD-ADQ-3** exhibited significant negative general combining ability effect for the same trait (Table1). The cross combination **TZBRD-ADQ-2** × **TZBRD-ADQ-3** showed significant SCA effect in the desirable direction. **TZBRD-ADQ-2** × **TZBRD-ADQ-4**, **TZBRD-ADQ-2** × **TZBRD-AD-5** and **TZBRD-ADQ-2** × **TZBRD-COMP-6** recorded desirable direction and no significant SCA effect (Table 2).

At Sawagi site, parent **TZBRD-COMP-6** showed high significant GCA effect for number of rows per ear in a desirable direction, but parent **TZBRD-ADQ-2** obtained a positive direction but no significant difference was recorded for GCA effect, but a negative direction and significant effect by **TZBRD-ADQ-3**, **TZBRD-ADQ-4** and **TZBRD-AD-5** (Table 3). The cross **TZBRD-ADQ-2**×**TZBRD-ADQ-4** and **TZBRD-ADQ-2**× **TZBRD-AD-5** showed highly significant specific combine ability effect in desirable direction. Whereas, **TZBRD-ADQ-2**×**TZBRD-ADQ-3**, **TZBRD-ADQ-2**×**TZBRD-COMP-6** and **TZBRD-AD-5**×**TZBRD-COMP-6** showed positive direction for SCA effect but without significance (Table 4). These results indicated that, crosses with high specific combining ability in desirable direction are obtained from parents with high GCA effects. Similar results were reported by Kalla *et al.* (2001) and Rajitha (2013). Thus, this trait can be improved by breeding methods involving simple selection like mass selection, ear- to-row method along with methods that exploits non-additive gene action.

#### **Number of Kernels/Row**

At Tacroof site, two parents **TZBRD-ADQ-4** and **TZBRD-COMP-6**, recorded high significant general combining ability effect in desirable direction for number of kernels per row while the other parent **TZBRD-ADQ-2** and **TZBRD-AD-5** showed negative direction. On the other hand, the parent **TZBRD-ADQ-3** showed positive direction for GCA effect with no significance for same trait (Table 1). The cross **TZBRD-ADQ-2**×**TZBRD-AD-5** and **TZBRD-ADQ-3** ×**TZBRD-AD-5** showed high significance in a positive direction in specific combining ability effects. Whereas, **TZBRD-ADQ-2**×**TZBRD-COMP-6**, **TZBRD-ADQ-3**×**TZBRD-ADQ-4** and **TZBRD-AD-5**×**TZBRD-COMP-6** (Table2). These results indicated that crosses with high specific combining ability in desirable direction are obtained from parents with high and low GCA effects, the same results reported by Kalla *et al.* (2001) and Rajitha (2013).

At the Sawagi site, **TZBRD-COMP-6** showed high positive significant GCA effect, while **TZBRD-ADQ-2** recorded negative significant effect and **TZBRD-ADQ-3** showed positive direction for GCA effect but it was not significant, among the ten crosses, only one cross recorded high significant in desirable direction was **TZBRD-ADQ-3×TZBRD-COMP-6** (Table 3), while the cross **TZBRD-ADQ-3×TZBRD-ADQ-4**, **TZBRD-ADQ-2×TZBRD-ADQ-4** and **TZBRD-ADQ-4×TZBRD-AD-5** were in desirable direction but were not significant SCA effect (Table 4) . The present results are in agree with the findings of Tollenaar and Lee (2004) and Frascaroli *et al.* (2007) whose also observed varying levels of heterosis for Number of kernels/row.

### 100 Kernels Weight

At Tacroof site, **TZBRD-AD-5** recorded high significant positive general combining ability effects for 100 kernel weight, while lines **TZBRD-COMP-6** recorded significant GCA effect in negative direction. Lines **TZBRD-ADQ-2** and **TZBRD-ADQ-3** showed positive direction with no significant GCA effect (Table 1). The cross combination **TZBRD-ADQ-2×TZBRD-ADQ-3** showed highest significant SCA effect in the desirable direction. Whereas **TZBRD-ADQ-3×TZBRD-ADQ-4**, **TZBRD-ADQ-3×TZBRD-COMP-6** and **TZBRD-ADQ-4×TZBRD-COMP-6** showed desirable direction for SCA effect but was not significant (Table 2).

At Sawagi site, **TZBRD-ADQ-2** and **TZBRD-AD-5** recorded high significant positive general combining ability effects for 100 kernel weight, while lines **TZBRD-ADQ-4** recorded significant GCA effect but in negative direction (Table 3). On the other hand, all crosses recorded non significant effect for specific combining ability, but some of them were in the desirable direction for SCA effects such as, **TZBRD-ADQ-2×TZBRD-ADQ-3**, **TZBRD-ADQ-2×TZBRD-ADQ-4**, **TZBRD-ADQ-2×TZBRD-AD-5**, **TZBRD-ADQ-3×TZBRD-ADQ-4**, **TZBRD-ADQ-3×TZBRD-AD-5**, **TZBRD-ADQ-3 × TZBRD-COMP-6**, **TZBRD-ADQ -4×TZBRD-AD-5** and **TZBRD-AD-5×TZBRD-COMP-6** (Table 4). However, these crosses come from parents having

high GCA. These findings were in conformity with Venugopal *et al.* (2003), Pavan *et al.* (2011) and Kumar *et al.* (2012a).

### **Grain Yield (t/ha)**

At Tacroof site-, **TZBRD-COMP-6** recorded significant positive general combining ability effects for grain yield (ton/ha), While the parental line **TZBRD-ADQ-2** was in a negative direction, but parent **TZBRD-ADQ-3** in positive direction without significant GCA effect for same trait (Table 1). The cross **TZBRD-ADQ-2**×**TZBRD-ADQ-3** recorded high significance in specific combining ability in desirable direction, whereas, **TZBRD-ADQ-2**×**TZBRD-ADQ-4** was in desirable direction but had non significant SCA effect (Table 2).

At Sawagi site, four parents recorded high positive general combining ability effect for grain yield these are **TZBRD-ADQ-4**, **TZBRD-ADQ-2**, and **TZBRD-COMP-6** and **TZBRD-ADQ-3** (Table 3). The cross combination **TZBRD-ADQ-2**×**TZBRD-COMP-6** showed the highest significant SCA effect followed by **TZBRD-ADQ-2**×**TZBRD-ADQ-3**, **TZBRD-AD-5**×**TZBRD-COMP-6**, **TZBRD-ADQ-2**×**TZBRD-AD-5**, and **TZBRD-ADQ-2** × **TZBRD-ADQ-4**, in the desirable direction (Table 4). These results indicated that crosses in desirable direction with high significance in specific combining ability are obtained from parents with high GCA effects. Han *et al.* (1991) and Vasal *et al.* (1992) identified several superior hybrids in an experiment included CIMMYT maize germplasm and reported that both specific combining ability (SCA) and general combining ability (GCA) effects were important for grain yield. In addition, Girma (1991) and Bayisa *et al.* (2008) reported on the significance of SCA effects and concluded that the predominance of non-additive genetic variance exist in yield.

**Table 1. Estimates of GCA Effects for Measured Traits on five Parental lines of Maize, at Tacroof site**

ENTRIES	DT	DS	PH	EH	EL	ED	NRE	NKR	KW	GY Kg/ha
TZBRD-ADQ-	0.66**	1.05**	-1.44**	-2.59**	-0.50**	-0.13**	-0.36**	-1.72**	0.17	-202.68**
TZBRD-ADQ-	-1.11**	-0.66**	-3.98**	-0.85	0.09	-0.06**	-0.28**	0.001	0.36	15.17
TZBRD-ADQ-	1.11**	1.18**	0.30**	2.97**	0.44**	0.09**	0.29**	0.65**	-0.21	-53.80
TZBRD-AD-5	-0.17	-0.94**	3.65**	2.35*	-0.60**	0.05**	0.12	-0.14	0.69**	-42.82
TZBRD-COMP-6	-0.49**	-0.63**	1.47**	-1.87	0.57**	0.04*	0.22**	1.20**	-1**	284.14**
SE±	0.24	0.46	1.33	2.36	0.16	0.04	0.14	0.56	0.39	95.69

- \*P=0.05, \*\*P=0.01

- DT: 50% tasseling (Tess (day), DS: 50% silking (Silk (day), PH: plant height, EH: ear height. El: ear length, Ed: ear diameter, NRE: number of rows per cob, NKR: number of kernels per row, KW: 100kernel weight and GY: grain yield.

**Table 2. Estimates of SCA Effects for the Measured Traits on 10 Crosses of Maize at Tacroof, (Combined)**

CROSSES(F1, hybrid)	DT	DS	PH	EH	EL	ED	NRE	NKR	KW	GY Kg/ha
TZBRD-ADQ-2× TZBRD-ADQ-3	-2.36**	-0.84	1.14	-6.45**	0.48*	0.14*	0.39*	-0.51	2.69**	972.77**
TZBRD-ADQ-2× TZBRD-ADQ-4	-0.42	-0.72	-8.36**	-7.38**	-0.32	0.02	0.11	-0.67	-0.06	133.28
TZBRD-ADQ-2× TZBRD-AD-5	0.19	0.028	9.14**	-1.39	0.79**	-0.01	0.13	2.78**	-1.30**	-487.17**
TZBRD-ADQ-2× TZBRD-COMP-6	0.19	0.30	0.33	-5.05**	0.004	0.09*	0.22	0.37	-0.44	-338.86**
TZBRD-ADQ-3× TZBRD-ADQ-4	1.10	0.36	-0.99	0.18	0.014	-0.049*	-0.03	0.10	0.41	-146.91
TZBRD-ADQ-3 × TZBRD-AD-5	0.56*	-0.09	5.29**	0.70**	0.75**	-0.18**	-0.31	2.09**	-0.83	-369.89**
TZBRD-ADQ-3× TZBRD-COMP-6	0.54	0.18	-3.53**	-1.31	-0.03	-0.08*	-0.23	-0.33	0.03	-494.28**
TZBRD-ADQ-4× TZBRD-AD-5	0.33	-0.02	8.44**	-1.77	0.35	-0.14*	-0.39*	0.79	-0.59	-335.78**
TZBRD-ADQ-4× TZBRD-COMP-6	0.40	0.34	-0.37	-5.04**	-0.29	-0.04	-0.28	-1.06**	0.27	-133.58
TZBRD-AD-5× TZBRD-COMP-6	-0.15	-0.12	5.90**	-4.69	0.44	-0.17**	-0.57**	0.93	-0.97	-180.25
SE±	0.61	1.18	3.42	6.08	0.50	0.10	0.36	1.44	1.0003	247.09

- \*P=0.05, \*\*P=0.01

- DT: 50% tasseling (Tess (day), DS: 50% silking (Silk (day), PH: plant height, EH: ear height. - El: ear length, Ed: ear diameter, NRE: number of rows per cob, NKR: number of kernels per row, KW: 100kernel weight and GY: grain yield.

**Table 3. Estimates of GCA Effects for Measured Traits on 5 Parental lines of Maize, at Sawagi.**

ENTRIES	DT	DS	PH	EH	EL	ED	NRE	NKR	KW	GY Kg/ha
TZBRD-ADQ-2	1.34**	1.31**	10.39**	-0.55	1.05**	0.04	0.06	-0.78**	0.47**	87.14**
TZBRD-ADQ-3	-1.62**	-1.31**	-3.93	2.70**	0.53**	0.12**	-0.13	0.09	0.10	58.78**
TZBRD-ADQ-4	-0.1	0.13	0.61	1.12	-0.86**	-0.01	-0.09	-0.09	-0.86**	256.37**
TZBRD-AD-5	0.10	-0.66	-6.59**	-3.52**	-0.74**	-0.09*	-0.26**	-0.32	0.32**	-484.69**
TZBRD-COMP-6	0.28	0.53	-0.48	0.25	0.02	-0.07**	0.42**	1.11**	-0.04	82.40**
SE±	0.65	0.82	6.05	1.59	0.44	0.06	0.23	0.74	0.30	15.35

- \*P=0.05, \*\*P=0.01

- DT: 50% tasseling (Tess day), DS: 50% silking (Silk day), PH: plant height, EH: ear height. - El: ear length, Ed: ear diameter, NRE: number of rows per cob, NKR: number of kernels per row, KW: 100kernel weight and GY: grain yield.

**Table 4. Estimates of SCA Effects for the Measured Traits on 10 Crosses of Maize at Sawagi, (combined)**

CROSSES (F1,hybrid)	DT	DS	PH	EH	EL	ED	NRE	NKR	KW	GY Kg/ha
TZBRD-ADQ-2× TZBRD-ADQ-3	1.67*	1.71	44.98**	-5.46**	3.36**	-0.03	0.18	-0.78	0.58	231.45**
TZBRD-ADQ-2× TZBRD-ADQ-4	-0.19	-0.82	-8.08	-3.42	-0.08	0.09	0.76**	0.09	0.41	60.23**
TZBRD-ADQ-2× TZBRD-AD-5	-0.98	-1.02	-7.83	0.17	-0.36	0.01	0.85**	-0.09	0.19	119.24**
TZBRD-ADQ-2× TZBRD-COMP-6	-0.24	-1.04	-7.63	-1.38	-0.48	-0.02	0.44	-0.33	-0.35	302.42**
TZBRD-ADQ-3× TZBRD-ADQ-4	-2.48**	-1.87	-23.46**	1.03	-1.26**	-0.24*	-1.36**	1.11	0.15	-438.904**
TZBRD-ADQ-3 ×TZBRD-AD-5	-3.26**	-2.07*	-23.21**	4.63**	-0.20	0.004	-0.02	-1.23	0.29	-280.73**
TZBRD-ADQ-3× TZBRD-COMP-6	-2.52**	-2.09*	-23.02**	3.07	-0.33	-0.03	-0.43	2.16**	0.27	-97.53**
TZBRD-ADQ-4× TZBRD-AD-5	0.63	0.83	2.18	-1.49	-0.39	-0.15*	-0.67**	0.08	0.54	-161.35**
TZBRD-ADQ-4× TZBRD-COMP-6	0.87	0.63	0.68	-3.84	-0.43	-0.18*	-0.76**	-0.95	-0.54	-414.88**
TZBRD-AD-5× TZBRD-COMP-6	0.58	0.52	3.15	-0.25	0.76	-0.02	0.34	-1.5	0.014	191.21**
SE±	1.67	2.11	15.62	4.12	1.15	0.16	0.59	1.91	0.78	24.66

- \*P=0.05, \*\*P=0.01

- DT: 50% tasseling (Tess day), DS: 50% silking (Silk day), PH: plant height, EH: ear height. - El: ear length, Ed: ear diameter, NRE: number of rows per cob, NKR: number of kernels per row, KW: 100kernel weight and GY: grain yield.

#### 4. CONCLUSIONS

It concluded that, studying combining ability effects has great importance in plant breeding as an effective means of selecting potential parents for hybridization and specific crosses.

For this study parents which evaluated at Sawagi site had a good general combining ability than genotypes evaluated at Kassala site.

Parent (**TZBRD-ADQ-2**) followed by (**TZBRD-COMP-6**) were the best general combiners for grain yield (ton/ha) and some of its components at Kassala site.

All Parents were possessed the best general combiner for grain yield (ton/ha) and some of its components at Sawagi site.

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## Combining Ability Analysis for Grain Yield and Some Agronomic Traits in Maize (*Zea mays* L.) Inbred Lines Throughout, Diallel Mating Design at Kassala State, Sudan

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### المستخلص

أجريت الدراسة الحالية في موقعين الأول بمزرعة تكروف التابعة لمحطة بحوث كسلا - ولاية كسلا والموقع الثاني بحقل مزارع بالسواقي - ولاية كسلا، بهدف دراسة القدرة المشتركة من خلال إختبار خمسة من الأباء وعشرة من السلالات الهجن لمعرفة الأثار الجينية التي تدخل في صفات أو سمات مختلفة لمحصول الذرة الشامية. الأباء: TZBRD-ADQ-2, TZBRD-ADQ-3, TZBRD-ADQ-4, TZBRD-AD-5 and TZBRD-COMP-6 الهجن: TZBRD-ADQ-4, × TZBRD-ADQ-3, TZBRD-ADQ-2× TZBRD-ADQ-2, TZBRD-COMP-6, TZBRD-× TZBRD-AD-5, TZBRD-ADQ-2×TZBRD-ADQ-2 ×TZBRD-AD-5, TZBRD-ADQ-3× TZBRD-ADQ-4, TZBRD-ADQ-3 ×ADQ-3 TZBRD-× TZBRD-AD-5, TZBRD-ADQ-4×TZBRD-COMP-6, TZBRD-ADQ-4 TZBRD-COMP-6×COMP-6 and TZBRD-AD-5. أجريت الدراسة بتنفيذ 4 تجارب لموسمين صيفيين متتالين 2016 - 2017 و2017-2018م شملت الصفات التي تم رصدها ودراستها عدد أيام 50%، الأمشاج المنكرة 50%، الطور الحريري، طول النبات (سم)، إرتفاع الكوز (سم)، طول الكوز (سم)، قطر الكوز (سم)، عدد الخطوط في الكوز، عدد الحبوب في السرابية، وزن المائة حبة (جم)، إنتاجية الحبوب (كجم/هكتار). أظهرت نتائج الدراسة لموقع

مزرعة تكروف - كسلا بالنسبة للأبء الخمسة المختارين للدراسة وجود تأثير معنوى عالى للأبء: **TZBRD-ADQ-3, TZBRD-COMP-6, TZBRD-ADQ-4** لكل الصفات المرغوبة بالدراسة ولذلك يمكن إستخدام الصفات ذات الصلة فى أى برنامج تربية لإستنباط أصناف هجن. كذلك أظهرت النتائج لموقع السواقى- كسلا أن نتائج الأبء: **TZBRD-ADQ-3, TZBRD-ADQ-2, TZBRD-COMP-6** لها أثر معنوى عالى للصفات المرغوبة عدد أيام 50%، الأمشاج المذكورة 50%، الطور الحريرى، طول الكوز (سم)، قطر الكوز(سم)، عدد الخسوط فى الكوز، عدد الحبوب فى السرابية، وزن المائة حبة (جم)، إنتاجية الحبوب (كجم/هكتار). نتائج الهجن بموقع مزرعة تكروف كسلا أظهرت تفوق الـ **TZBRD-ADQ-2, TZBRD-ADQ-3** فى كل الصفات المرغوبة المرصودة فى الدراسة عدا صفات عدد أيام 50%، الطور الحريرى، طول النبات (سم)، عدد الحبوب فى السرابية. موقع السواقى-كسلا أظهرت النتائج من الدراسة تفوق الهجن **TZBRD-ADQ-3, TZBRD-COMP-6** بتأثير معنوى للصفات المرغوبة عدد أيام 50% الأمشاج المذكورة 50% الطور الحريرى، طول النبات (سم) وعدد الحبوب فى السرابية. ويأتى ثانياً الهجن **TZBRD-ADQ-2, TZBRD-ADQ-3** بالنسبة لصفات إرتفاع الكوز، طول الكوز وإنتاجية الحبوب (كجم/هكتار) بأثر معنوى.

**كلمات مفتاحية:** التباين؛ تزواج الداياليل؛ القدرة؛ كسلا.

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