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# TOP-CROSSES ANALYSIS FOR SELECTING MAIZE LINES IN THE EARLY SELF GENERATIONS

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***ABSTRACT:*** *Twenty selected $S_3$ white maize lines derived from the wide genetic base population Composite-5 (Cycle-3), were topcrossed to each of two white maize inbred testers, i.e. Sd 7 and Sd 63. The 40 topcrosses were evaluated in 2000 growing season at Gemmeiza and Sids Agric. Res. Stations. The data were abdained for grain yield, number of ears/plant, resistance to late wilt disease, silking date, plant height and ear height. Testers contributed much more than the lines to the total genetic variation and were more affected by the environmental conditions. The inbred testers ranked the 20 lines differently. Parental lines L-4, L-9, L-11, L-13, L-14, L-17, L-19 and L-20 were found to be the best general combiners for high yielding ability. L-11, L-13, L-14, L-15 and L-19 were significantly better general combiners for prolificacy. Parental females L-7, L-9, L-12 and L-13 were good donors for resistance to late wilt disease. Meanwhile, L-11, L-13, L-15, L-16, L-17, L-18, L-19 and L-20 were significantly better general combiners for earliness, as well as, L-2, L-7 and L-15 were good donors for shortness and lower ear placement. Inbred tester Sd 7 manifested highest average performance of grain yield compared to testcrosses of Sd 63. Results showed that three crosses of Sd 7 with inbreds L-17, L-16 and L-14 significantly outyielded the best commercial check hybrid SC 10 (29.68 ard/fed) by 6.7, 4.9 and 4.1 ard/fed, respectively. Furthermore, the most outstanding crosses; (L-16 x Sd 7 and L-17 x Sd 7) showed positive and significant specific combining abitily SCA effects for grain yieldp. The greatest inter and intra allelic interaction in terms of SCA were observed in 10 out of 40 testcrosses for grain yield, 6 crosses for prolificacy, 3 crosses for late wilt resistance, 9 crosses for earliness.*

*The magnitude of the ratio of general to specific combining ability variances ($k^2$ gca/$k^2$ sca) revealed that the non-additive component of gene action had the major role in the inheritance of all studied traits. Furthermore, the magnitude of the interactions between $k^2$ sca x Locations was higher than that of $k^2$ gca x Locations for grain yield, silking date and ear height. However, the latter was markedly higher than that of $k^2$ for the other three traits.*

*Key words: Maize, Tester, Inbred, Testcross, Combining ability, Variance*

## INTRODUCTION

Utilizing new maize inbred lines in the National Maize Breeding Program is considered among the main objectives to develop and release high yielding hybrids, resistant to late wilt disease and with desirable agronomic characters to overcome the increasing demands of maize consumption for bread industry, livestock and poultry feeding. Procedures for developing and improving inbred lines of maize were reported by Geadlman and Peterson (1976) and Kuhn and Stucker (1976) who stated that improving inbred lines increased grain yield and modified maturity of their hybrids. Moreover, Bauman (1981) indicated that the most logical sequel is to cross pairs of lines that complement one another to produce the $F_2$ generation ($F_2$ population) of specific single crosses which are used most frequently as a source of new inbred lines development. If one parent of such single cross is decidedly better than the other one, the chance of obtaining a derivative line superior to the better parent is remoted (Bailey and Comstock, 1976).

The standard topcross procedure as suggested by Davis (1927) has been widely used to evaluate the combining ability of inbred lines in hybrid maize breeding programs. Inbreds of high general combining ability are crossed to detect particular combinations that result in superior single cross, i.e., two-line combinations for commercial use. The choice of suitable testers for testing the developed inbred lines is an important decision. Darrah *et al.* (1972) and Horner *et al.* (1973) reported that inbred testers have the advantage of no sampling errors of genetic variability within the testers and greater genetic variation among testcrosses. Furthermore, Russell *et al.* (1973) and Zambezi *et al.* (1986) suggested that inbred testers could be used successfully for improving general combining abibility GCA, as well as, SCA in maize.

Several results concerning the genetic analysis of grain yield, as well as, other agronomic traits reported by El-Itriby *et al.* (1990)b indicated that the relative importance of different components of genetic variance may vary with the type of genetic materials under study. Studies conducted with homozygous base populations indicated the importance of over dominance in grain yield performance (Gardner and Lonnquist, 1959 and Shehata *et al.*, 1982). Moreover, Shehata and Dhawan (1975) and Sadek *et al.* (2000) found that SCA effects were more important than GCA effects in the inheritance of grain yield.

The current study was carried out with the objectives of:(i) evaluating general (GCA) and specific (SCA) combining ability effects and type of gene action involved in the manifestation of grain yield and some other attributes of twenty newly developed white inbred lines and two inbred testers and (ii) identify the most superior line(s) and single crosses for further use in the breeding program.

## MATERIALS AND METHODS

Twenty selected white maize lines in S3 generetion derived from the wide genetic base population Composite-5 (Cycle-3) through selection from segregating generations in the disease nursery field at Gemmeiza Agric. Res.

Station, were used for the purpose of this study. Composite-5 was developed from Pop.Sids 7444, which was developed from American Early Dent (AED) x Tuxpeno. In 1999 growing season, the 20 lines were topcrossed to each of two narrow base inbred testers viz., Sids 7 (Sd 7) and Sids 63 (Sd 63) at Gemmeiza Experimental Station. The two testers are being used in seed production of commercial single and three way cross hybrids. In 2000 growing season, the 40 resultant testcrosses along with two commercial check hybrids; SC10 and SC122 were evaluated in replicated yield trials conducted at Gemmeiza and Sides Agricultural Research Stations. A randomized complete block design with four replications was used at each location. Plot size was one row 6 m long and 80 cm apart. Planting was in hills, spaced 25 cm along the ridge. Two kernels were planted per hill and thinned later to one plant per hill to provide a population of approximately 22,000 plants/feddan (feddan = 4200 $m^2$). All cultural practices were applied as recommended at the proper time. Data were recorded for number of days to 50% silking, Plant height (cm), ear height (cm), resistance to late wilt disease (%), number of ears/100 plants, and grain yield in ard./fed. adjusted to 15.5% grain moisture and converted to ardab/feddan (ardab = 140Kg). Analysis of variance was performed for the combined data over locations according to Steel and Torrie (1980) and procedure, was further followed to Kempthorne (1957) obtain information about the combining ability of the lines and the testers and to also estimate type of gene effects controlling grain yield and other studied traits in the tested lines.

Half-Sib and full–sib covariance and hence the variances due to general (G.C.A.) and specific (S.C.A.) combining ability were estimated as follows:

$\text{Cov. H.S.} = (m\,\sigma^2 f + f\,\sigma^2 m) / m + f$

$\text{Cov. F.S.} = \sigma^2 f\, m + 2\ \text{Cov. H.S.}$

$\sigma^2\text{G.C.A.} = \text{Cov. H.S.}$

$\sigma^2\text{S.C.A} = (\text{Cov. F.S.} - 2\ \text{Cov. H.S.}) = \sigma^2 f\, m$

$\sigma^2\text{G.C.A. x Loc.} = m\,\sigma^2 f\, l + f\,\sigma^2 m\, l) / m + f$

$\sigma^2\text{S.C.A. x Loc.} = \sigma^2 m\, f\, l$

Where: m = testers, f = lines and l= locations.

## RESULTS AND DISCUSSION

Bartlett Test of homogeneity of error mean squares of different revealed no significant differences between the error variances of different locations. Therefore the data of combined over locations are presented. Analysis of variance for the six studied traits based on combined data (Table 1) indicate that the differences between locations were highly significant for all traits, indicating that the two locations differed in their environmental conditions. Highly significant differences were detected among lines, testers and testcrosses for all studied traits. These results indicated greater diversity existed among testers and lines in order of performance in testcrosses. In addition, the interactions of lines, testers and lines x testers with locations were highly significant for all traits, except plant height, days to 50% silking for testers x locations and late wilt resistance for lines x locations and lines x testers x locations interactions. These interactions with locations are indicative that the studied lines and testers performed differently at the two locations. These results indicate that it is worthwhile to evaluate testcrosses at many environments, especially for grain yield, which is regarded as complex polygenic trait (Darrah and Hallauer, 1972). The obtained results are in the same lines with those previously reached by El-Itriby *et al.* (1990)b, Salama *et al.* (1995), Sadek *et al.* (2000) and Soliman *et al.* (2001).

Table (1): Analysis of variance for grain yield and other traits of 20 lines topcrossed with two testers, combined over two locations, in 2000 growing season.

| SOV | df | Grain yield | Ears/100 plants | Days to mid silking | Plant height | Ear height | L.W resistance % |
|---|---|---|---|---|---|---|---|
| Locations (Loc) | 1 | 6200.21** | 15398.2** | 54.45** | 38522.2** | 19593.8** | 130.56* |
| Rep/(Loc) | 6 | 22.37 | 93.9 | 9.09 | 1125.0 | 1611.0 | 78.45 |
| Lines (L) | 19 | 213.56** | 728.7** | 58.26** | 1019.6** | 505.2** | 121.88** |
| Testers (T) | 1 | 2377.24** | 11177.0** | 432.45** | 1642.6** | 1629.0** | 513.59** |
| L x T | 19 | 200.95** | 1211.3** | 27.63** | 1671.8** | 1424.5** | 157.66** |
| L x Loc | 19 | 42.53** | 479.7** | 3.24** | 192.4 | 125.7* | 44.29 |
| T x Loc | 1 | 746.13** | 3752.3** | 0.45 | 212.9 | 2194.5** | 176.42** |
| L x T x Loc | 19 | 68.98** | 258.6** | 4.98** | 94.0 | 227.9** | 32.39 |
| Pooled error | 234 | 10.83 | 132.7 | 1.66 | 125.3 | 68.8 | 28.60 |
| CV.% |  | 13.30 | 11.07 | 2.02 | 4.36 | 5.82 | 5.56 |

*,** Indicate significant differences at 0.05 and 0.01 levels of probability, respectively.

The magnitude of the variance due to testers and testers x locations interaction for all studied traits was higher than variance of lines and lines x locations interaction, respectively. This indicates that the testers contributed much more to the total variation and were more affected by the environmental conditions than the lines. Similar findings were obtained by El-Itriby *et al.* (1990)a and Soliman *et al.* (2001).

Grain yield of the 20 lines across the two testers (Table 2) ranged from 16.27 to 31.28 ardab/feddan for testcrosses with lines L-7 and L-17, respectively. The most preferable lines were L-4, L-9, L-11, L-13, L-14, L-16, L-17, L-18, L-19 and L-20. These lines produced the highest average grain yield (ranging from 25.56 to 31.28 ard/fed). Grain yield of two lines, L-14 and L-17 across the two testers and six testcrosses of Sd 7 with lines L-4, L-13, L-14, L-16, L-17 and L-18 significantly outyielded the commercial check hybrid SC 122 (26.54 ard/fed.) with minimum of 3.54 ard/fed (13.3%) and maximum of 9.80 ard/fed (36.9%). Furthermore, the three top-most outyielding crosses, i.e. L-17 x Sd 7, L-16 x Sd 7 and L-14 x Sd 7 gave the highest grain yield and significantly outyielded the best commercial hybrid SC 10 (29.68 ard/fed ) by 6.66, 4.85 and 4.06 ard/fed, respectively. Considering the inbred testers, tester line Sd 7 produced higher grain yield (27.46 ard/fed) over all parental lines than the tester line Sd 63 (22.01 ard/fed). These results were reflected in the combining ability effects (Table 3), where L-17 and L-14 were the best lines in GCA effects, (which had good yield in their crosses with the two testers) followed by L-13, L-4, L-19, L-9, L-11, L-20, L-18 and L-16. The inbred tester Sd 7 had also highly significant and postive GCA effect, whereas the inbred tester Sd 63 had a high negative value in its GCA effect for grain yield. In other words, the above mentioned 10 lines in addition to the inbred tester Sd 7 had accumulated favorable alleles for grain yield and contributed to upgrading grain yield of all crosses involving these lines. Similar findings were obtained by Diab *et al.* (1994), Salama *et al.* (1995) and Sadek *et al.* (2000) for the two inbred testers. Comparison of SCA effects Table (4) indicated that significantly positive estimates were detected for 10 out of the 40 testcrosses. The most outstanding testcrosses (L-17 x Sd 7, L-16 x Sd 7 and L-18 x Sd 7), which gave 36.34, 34.53 and 32.10 ard/fed. are included among these 10 crosses. The other 7 testcrosses, however were lower in grain yield, but not significantly less than SC 10, except L-12 x Sd7, L-7 x Sd 63 and L-8 x Sd 63. Testcross which rank highest for SCA effects in a ceration trait and in the same time ranks best in its performance are considered to be good breeding materials to improve this trait. Thus, the crosses (L-16 x Sd 7, L-17 x Sd 7 and L-18 x Sd 7) appeared to be a promising single crosses, since they had positively significant SCA effects (Table 4) and outyielded the best commercial hybrid SC 10 (Table 2). It is worth noting that a cross exhibiting high SCA may come from two parents possessing good GCA or from one parent with good GCA and another with poor GCA. For example the best SCA effects for grain yield was exhibited between parents with poor and good GCA, L-3 x Sd 7, L-9 x Sd 63, L-11 x Sd 63, L-12 x Sd 7, L-16 x Sd 7 and L-18 x Sd 7. Similar findings were obtained by Nawar *et al.* (1979), Nawar and El-Hosary (1985) and Soliman *et al.* (2001).

In respect of number of ears per 100 plants, deta of Tables (2 and 3) illustrated that the tester line Sd 7 showed more favorable effect on number of ears than the tester line Sd 63, since it manifested significantly higher average number of ears/plant and highly significant positive GCA effect. These results are supported by the finding of Sadek *et al.* (2000). For the tested lines, the best general combiners over testers were L-11, L-13, L-14, L-15 and L-19, since they exhibited more ears/plant and had highly significant positive GCA effects (Tables 2 & 3). On the other hand, lines L-2, L-3, L-5, L-6, L-8, L-10, L-12 and L-18 showed negative and significant GCA effects in direction of lower ears/plant.

Considering the testcrosses, data of Table (2) showet that average ears number ranged from 82.4 to 133.0 ears/100 plants for crosses L-3 x Sd 63, and L-15 x Sd 7, respectively. In general, all testcrosses involving the inbred tester Sd 7 showed more ears/plant than those involving the tester line Sd 63. The difference between the two checks, SC10 (113.8 ears/100 plants) and SC 122 (109.5 ears/100 plants) was insignificant. However, three testcrosses of Sd 7 with lines L-11, L-15, and L-19 exhibited significantly more ears/plant than SC10 in addition to the testcross L-14 x Sd 7, which significantly exceeded SC122. Six testcrosses, *i.e.* L-3 x Sd 7, L-6 x Sd 63, L-7 x Sd 63, L-15 x Sd 7, L-18 x Sd 7 and L-19 x Sd 7 showed positive and significant SCA effects for number of ears/100 plants (Table 4).

Considering number of days to 50% silking, data of Tables (2 and 3) confirmed that the inbred tester Sd 7 was significantly earlier than the tester line Sd 63 and had highly significant GCA effects towards earliness. In other words, testcrosses involving the line were earlier. This indicates that the inbred possess favorable genes for earliness. On the contrary, parental lines L-1, L-4, L-5, L-6, L-7, L-8, L-10, L-12 and L-14 had positive and highly significant GCA effects marked by lateness in silking appearance. For testcrosses, data of Table (2) reveals at that 23 out of the 40 testcrosses exhibited significantly earlier silking date than the commercial check SC10. However, data of Table (4) showed that the best specific combinations, negatively significant SCA effects resulted from five testcrosses of Sd 7 with lines L-1, L-2, L-3, L-7 and L-14 and four testcrosses of Sd 63 with lines L-10, L-11, L-12 and L-20 conforming their earliness. On the other hand, nine testcrosses had positively significant SCA effects in relation to lateness.

Considering plant height, average performance (Table 2) revealed that tester line Sd 63 induced shorter plants over all parental lines, and had significant negative (desirable) GCA effects than the tester line Sd 7 (Table 3). This result indicates that Sd 63 had favorable dominant genes for shortness. Similar findings were obtained by Diab *et al.* (1994), Salama *et al.* (1995) and Sadek *et al.* (2000). For the parental lines, the best general combiners were L-2, L-3, L-7 and L-15, since they had highly significant negative (desirable) GCA effects and the shortest plants (Tables 2 & 3).

Plant height of the 40 testcrosses (Table 2) ranged from 222.7 to 288.1 cm for crosses L-7 x Sd 7 and L-17 x Sd 7, respectively. Nine out of the 40 testcrosses, *i.e.* L-1 x Sd 63, L-3 x Sd 7, L-6 x Sd 7, L-7 x Sd 7, L-10 x Sd 63, L-14 x Sd 7, L-16 x Sd 63, L-17 x Sd 63 and L-18 x Sd 63 exhibited negative and significant SCA effects in direction to shortness (Table 4). Moreover, all the above mentioned testcrosses, except L-10 x Sd 7, L-17 x Sd 63 and L-18 x Sd 63 were significantly shorter than SC 122 (256.0 cm) Table (2).

**Table (2): Mean performance of 40 topcrosses between 20 lines and two testers for grain yield and other agronomic traits, combined over locations, in 2000 growing season.**

| Lines | Grain yield (ard/fed) | | | No of ears / 100 plants | | | Days to mid silking | | |
|---|---|---|---|---|---|---|---|---|---|
| | Sd 7 | Sd 63 | Mean | Sd 7 | Sd 63 | Mean | Sd 7 | Sd 63 | Mean |
| L-1 | 26.08 | 19.01 | 22.55 | 111.5 | 93.5 | 102.5 | 62.1 | 69.5 | 65.8 |
| L-2 | 27.10 | 21.64 | 24.37 | 107.9 | 98.6 | 103.2 | 61.5 | 66.9 | 64.2 |
| L-3 | 29.61 | 17.02 | 23.31 | 113.9 | 82.4 | 98.1 | 62.4 | 66.5 | 64.4 |
| L-4 | 31.41 | 24.32 | 27.87 | 113.4 | 100.3 | 106.9 | 64.4 | 66.9 | 65.6 |
| L-5 | 28.26 | 20.21 | 24.24 | 96.7 | 98.8 | 97.7 | 63.5 | 66.7 | 65.1 |
| L-6 | 15.65 | 26.35 | 21.00 | 89.8 | 105.7 | 97.8 | 63.4 | 67.4 | 65.4 |
| L-7 | 12.10 | 20.43 | 16.27 | 82.7 | 116.0 | 99.3 | 64.1 | 68.5 | 66.3 |
| L-8 | 20.10 | 22.29 | 21.19 | 101.7 | 94.8 | 98.3 | 64.4 | 68.2 | 66.3 |
| L-9 | 26.38 | 27.48 | 26.93 | 101.3 | 99.8 | 100.5 | 63.4 | 64.0 | 63.7 |
| L-10 | 24.49 | 16.82 | 20.66 | 103.4 | 90.0 | 96.7 | 68.1 | 64.7 | 66.4 |
| L-11 | 26.86 | 27.03 | 26.93 | 125.4 | 107.0 | 116.2 | 61.7 | 62.0 | 61.9 |
| L-12 | 25.56 | 14.69 | 20.13 | 95.9 | 96.6 | 96.2 | 64.5 | 64.6 | 64.6 |
| L-13 | 32.59 | 24.49 | 28.54 | 120.0 | 101.1 | 110.6 | 61.0 | 62.5 | 61.7 |
| L-14 | 33.74 | 26.41 | 30.08 | 120.8 | 110.5 | 115.7 | 61.7 | 68.4 | 65.1 |
| L-15 | 29.76 | 20.13 | 24.94 | 133.0 | 93.0 | 113.0 | 61.5 | 63.7 | 62.6 |
| L-16 | 34.53 | 16.59 | 25.56 | 117.9 | 96.8 | 107.3 | 62.7 | 63.4 | 63.1 |
| L-17 | 36.34 | 26.23 | 31.28 | 120.7 | 96.8 | 108.7 | 61.5 | 62.6 | 62.1 |
| L-18 | 32.10 | 19.59 | 25.85 | 111.2 | 82.9 | 97.0 | 60.0 | 62.2 | 61.1 |
| L-19 | 28.93 | 25.12 | 27.02 | 129.4 | 95.2 | 112.3 | 60.0 | 61.4 | 61.9 |
| L-20 | 27.58 | 25.28 | 26.43 | 102.7 | 102.9 | 102.8 | 61.7 | 60.5 | 61.1 |
| Average | 27.46 | 22.01 | | 110.0 | 98.1 | | 62.7 | 65.0 | |
| Checks | | | | | | | | | |
| SC 10 | | 29.68 | | | 113.8 | | | 65.0 | |
| SC 122 | | 26.54 | | | 109.5 | | | 64.0 | |
| LSD | | | | | | | | | |
| 0.05 | | 3.23 | | | 11.29 | | | 1.26 | |
| 0.01 | | 4.23 | | | 14.80 | | | 1.65 | |

Table 2. Cont.

| Lines | Plant height | | | Ear height | | | Late wilt resistance % | | |
|---|---|---|---|---|---|---|---|---|---|
| | Sd 7 | Sd 63 | Mean | Sd 7 | Sd 63 | Mean | Sd 7 | Sd 63 | Mean |
| L-1 | 266.1 | 238.9 | 252.5 | 140.5 | 142.2 | 141.4 | 97.9 | 93.9 | 95.9 |
| L-2 | 239.0 | 264.9 | 242.9 | 144.4 | 129.2 | 136.8 | 89.6 | 97.2 | 93.4 |
| L-3 | 239.6 | 254.7 | 247.2 | 150.0 | 128.4 | 139.2 | 89.5 | 95.3 | 92.4 |
| L-4 | 275.4 | 259.1 | 267.2 | 157.0 | 142.1 | 149.6 | 92.4 | 94.8 | 93.6 |
| L-5 | 265.0 | 265.9 | 265.4 | 162.6 | 141.1 | 151.9 | 99.0 | 97.9 | 98.4 |
| L-6 | 238.9 | 264.2 | 251.6 | 154.0 | 127.5 | 140.7 | 96.8 | 97.4 | 97.1 |
| L-7 | 222.7 | 265.1 | 243.9 | 155.0 | 113.2 | 134.1 | 99.5 | 100.0 | 99.7 |
| L-8 | 254.2 | 259.5 | 256.9 | 154.1 | 138.4 | 146.2 | 94.7 | 98.8 | 96.7 |
| L-9 | 255.5 | 259.5 | 257.5 | 140.7 | 136.7 | 138.7 | 99.0 | 100.0 | 99.5 |
| L-10 | 268.0 | 243.9 | 255.9 | 129.0 | 161.0 | 145.0 | 99.4 | 93.8 | 96.6 |
| L-11 | 254.2 | 258.6 | 256.4 | 143.0 | 139.5 | 141.2 | 78.4 | 100.0 | 89.2 |
| L-12 | 269.6 | 261.2 | 265.4 | 140.0 | 144.5 | 142.2 | 98.8 | 99.3 | 99.1 |
| L-13 | 260.7 | 252.0 | 256.4 | 136.5 | 146.6 | 141.5 | 100.0 | 100.0 | 100.0 |
| L-14 | 255.9 | 268.7 | 262.3 | 133.2 | 160.7 | 147.0 | 93.7 | 99.5 | 96.6 |
| L-15 | 250.1 | 245.2 | 247.7 | 133.9 | 134.1 | 134.0 | 90.5 | 97.7 | 94.1 |
| L-16 | 286.1 | 242.0 | 264.1 | 163.6 | 134.2 | 148.9 | 98.0 | 94.4 | 96.2 |
| L-17 | 288.1 | 258.9 | 273.4 | 147.0 | 160.6 | 153.8 | 96.3 | 99.5 | 97.9 |
| L-18 | 270.0 | 246.6 | 258.3 | 135.9 | 144.1 | 140.0 | 97.9 | 95.0 | 96.5 |
| L-19 | 263.1 | 247.5 | 255.3 | 133.4 | 141.4 | 137.4 | 88.6 | 99.5 | 94.0 |
| L-20 | 257.5 | 250.6 | 254.1 | 140.0 | 137.7 | 138.9 | 99.4 | 96.0 | 97.7 |
| Average | 259.0 | 254.5 | | 144.7 | 140.2 | | 95.0 | 97.5 | |
| Checks | | | | | | | | | |
| SC 10 | | 274 | | | 153.4 | | | 100.0 | |
| SC 122 | | 256 | | | 145.9 | | | 99.5 | |
| LSD | | | | | | | | | |
| 0.05 | | 10.97 | | | 8.13 | | | 5.24 | |
| 0.01 | | 14.38 | | | 10.66 | | | 6.87 | |

Considering ear height, results obtained in Tables (2 and 3) revealed that the tester line Sd 63 showed more favorable effect on ear height than the tester line Sd 7, since it manifested significantly lower average ear height and highly significant negative GCA effect. These results support the findings of Diab *et al.* (1994) and Sadek *et al.* (2000). For the tested lines across the two testers, L-2, L-7, L-15, and L-19 showed significantly the lowest ear height (136.8, 134.1, 134.0 and 137.4 cm, respectively), which corresponded with their highly significant negative. GCA effects. On the other hand, five parental lines (L-4, L-5, L-14, L-16 and L-17) exhibited the highest average for ear height (149.6, 151.9, 147.0, 148.9 and 153.8 cm, respectively), with highly significant positive

GCA effects. Ear height of the 40 testcrosses (Table 2) ranged from 113.2 to 163.6 cm for crosses L-7 x Sd 63 and L-16 x Sd 7, respectively. Twenty eight out of the 40 topcrosses were significantly lower in ear placement than the commercial check SC 10 (153.4 cm). However, 14 topcrosses, viz. 6 topcrosses of Sd 7 with lines L-10, L-13, L-14, L-15, L-18 and L-19, in addition to 8 topcrosses of Sd 63 with lines L-2, L-3, L-6, L-7, L-9, L-15, L-16 and L-20 exhibited lower ear placement than SC 122 (145.9 cm). Though, the difference between the two checks was insignificant. Regarding SCA effects, 11 topcrosses, i.e. L-3 x Sd 63, L-5 x Sd 63, L-6 x Sd 63, L-7 x Sd 63, L-10 x Sd 7, L-13 x Sd 7, L-14 x Sd 7, L-16 x Sd 63, L-17 x Sd 7, L-18 x Sd 7 and L-19 x Sd 7 showed negatively significant SCA effects towards low ear placement (Table 4). On the contrary the highest positive SCA effects, towards high ear placement were shown in the topcrosses L-3 x Sd 7, L-5 x Sd 7, L-6 x Sd 7, L-7 x Sd 7, L-10 x Sd 63, L- 13 x Sd 63, L-14 x Sd 63, L-16 x Sd 7, L-17 x Sd 63, L-18 x Sd 63 and L-19 x Sd 63.

With respect to percent of resistance to late wilt disease (Table 2) performance of the 20 lines across the two testers ranged from 89.2% (low resistant) to 100% (high resistant) for lines L-11 and L-13, respectively.

Table 3. General combining ability effects ($\hat{g}_i$) of 20 inbred lines and two testers for the studied traits, combined over two locations, in 2000 growing season.

| Genotypes | | Grain yield | Ears/100 plants | Days to mid silking | Plant height | Ear height | L.W resistance % |
|---|---|---|---|---|---|---|---|
| Lines | L-1 | -2.187** | - 1.556 | 1.937** | - 4.228 | - 1.062 | -0.309 |
| | L-2 | -0.363 | - 8.14** | 0.312 | -13.791** | - 5.625** | -2.841* |
| | L-3 | -1.417 | - 5.901* | 0.562 | - 9.541** | - 3.250 | -3.847** |
| | L-4 | 3.134** | 2.826 | 1.750** | 10.522** | 7.125** | -2.628* |
| | L-5 | -0.496 | - 6.298* | 1.250** | 8.709** | 9.437** | 2.197 |
| | L-6 | -3.731** | - 6.273* | 1.500** | - 5.166 | - 1.687 | 0.884 |
| | L-7 | -8.465** | - 4.707 | 2.437** | -12.791** | - 8.312** | 3.497** |
| | L-8 | -3.539** | - 5.783* | 2.437** | 0.147 | 3.812 | 0.509 |
| | L-9 | 2.202** | - 3.497 | -0.187 | 0.772 | - 3.687 | 3.253* |
| | L-10 | -4.077** | - 7.386* | 2.562** | - 0.792 | 2.562 | 0.372 |
| | L-11 | 2.199** | 12.159** | -2.00** | - 0.291 | - 1.187 | -7.016** |
| | L-12 | -4.605** | - 7.818** | 0.687* | 8.709** | - 0.187 | 2.859* |
| | L-13 | 3.812** | 6.510* | -2.125** | - 0.353 | - 0.875 | 3.766** |
| | L-14 | 4.843** | 11.617** | 1.187** | 5.584* | 4.562* | 0.347 |
| | L-15 | 0.213 | 8.955** | -1.250** | - 9.041** | - 8.437** | -2.141 |
| | L-16 | 0.829 | 3.289 | -0.812* | 7.334** | 6.500** | -0.034 |
| | L-17 | 6.552** | 4.703 | -1.812** | 16.709** | 11.375** | 1.653 |
| | L-18 | 1.116 | - 7.016* | -2.750** | 1.584 | - 2.437 | 0.241 |
| | L-19 | 2.285** | 8.234** | -2.937** | - 1.416 | - 5.062* | -2.209 |
| | L-20 | 1.695* | - 1.246 | -2.750** | - 2.666 | - 3.562 | 1.447 |
| Testers | Sd 7 | 2.726** | 5.910** | -1.162** | 2.266* | 2.256** | -1.267** |
| | Sd 63 | -2.726** | - 5.910** | 1.162** | - 2.266* | - 2.256** | 1.267** |
| SE for | | | | | | | |
| Lines $\hat{g}_i$ | | 0.823 | 2.880 | 0.322 | 2.798 | 2.074 | 1.337 |
| $\hat{g}_i - \hat{g}_j$ | | 1.163 | 4.073 | 0.455 | 3.957 | 2.932 | 1.891 |
| Testers $\hat{g}_i$ | | 0.260 | 0.911 | 0.102 | 0.885 | 0.656 | 0.423 |
| $\hat{g}_i - \hat{g}_j$ | | 0.368 | 1.288 | 0.144 | 1.251 | 0.927 | 0.598 |

*,** Indicate significant differences at 0.05 and 0.01 levels of probability, respectively.

Table. (4):Specific combining ability effects ($\hat{S}_{ij}$) of 40 topcrosses for the studied traits, combined over 2 locations in 2000 growing season.

| Testcrosses | Grain yield | Ears/100 plants | Days to 50 % silking | Plant height | Ear height | L.W resistance % |
|---|---|---|---|---|---|---|
| L-1 x Sd 7 | 0.811 | 3.101 | - 2.525** | 11.359** | - 3.131 | 3.254 |
| L-2 x Sd 7 | 0.006 | 1.274 | - 1.525** | - 6.203 | 5.306 | -2.539 |
| L-3 x Sd 7 | 3.571** | 9.836* | - 0.900* | - 9.828* | 8.556** | -1.621 |
| L-4 x Sd 7 | 0.818 | 0.643 | - 0.088 | 5.859 | 5.181 | 0.086 |
| L-5 x Sd 7 | 1.302 | - 6.972 | - 0.463 | - 2.703 | 8.494** | 1.798 |
| L-6 x Sd 7 | -8.080** | -13.858** | - 0.838 | -14.953** | 10.994** | 0.998 |
| L-7 x Sd 7 | -6.893** | -22.564** | - 1.025* | -23.453** | 18.619** | 0.998 |
| L-8 x Sd 7 | -3.819** | - 2.427 | - 0.775 | - 4.891 | 5.619 | -0.754 |
| L-9 x Sd 7 | -3.276** | - 5.156 | 0.850 | - 4.266 | - 0.256 | 0.754 |
| L-10 x Sd 7 | 1.113 | 0.789 | 2.850** | 9.797* | -18.256** | 4.061* |
| L-11 x Sd 7 | -2.821* | 3.292 | 1.038* | - 4.453 | - 0.506 | -9.514** |
| L-12 x Sd 7 | 2.706* | - 6.274 | 1.100* | 1.922 | 2.631 | 1.023 |
| L-13 x Sd 7 | 1.323 | 3.499 | 0.413 | 2.109 | - 7.319* | 1.267 |
| L-14 x Sd 7 | 1.441 | - 0.759 | - 2.150** | - 8.703* | -11.494** | -1.652 |
| L-15 x Sd 7 | 2.089 | 14.057** | 0.038 | 0.172 | - 2.381 | -2.364 |
| L-16 x Sd 7 | 6.246** | 4.652 | 0.850 | 19.797** | 16.944** | 3.067 |
| L-17 x Sd 7 | 2.328* | 6.034 | 0.600 | 12.297** | - 9.069** | -0.346 |
| L-18 x Sd 7 | 3.527** | 8.217* | 0.038 | 9.422* | - 6.381* | 2.692 |
| L-19 x Sd 7 | -0.817 | 11.172** | 0.725 | 5.547 | - 6.256* | -4.183* |
| L-20 x Sd 7 | -1.576 | - 6.007 | 1.788** | 1.172 | - 1.131 | 2.986 |
| L-1 x Sd 63 | -0.811 | - 3.101 | 2.525** | -11.359** | 3.131 | -3.254 |
| L-2 x Sd 63 | -0.006 | 1.274 | 1.525** | 6.203 | - 5.306 | 2.539 |
| L-3 x Sd 63 | -3.571** | - 9.836* | 0.900* | 9.828* | - 8.556** | 1.621 |
| L-4 x Sd 63 | -0.818 | - 0.643 | 0.088 | - 5.859 | - 5.181 | -0.086 |
| L-5 x Sd 63 | -1.302 | 6.972 | 0.463 | 2.703 | - 8.494** | -1.798 |
| L-6 x Sd 63 | 8.080** | 13.858** | 0.838 | 14.953** | -10.994** | -0.998 |
| L-7 x Sd 63 | 6.893** | 22.564** | 1.025* | 23.453** | -18.619** | -0.998 |
| L-8 x Sd 63 | 3.819** | 2.427 | 0.775 | 4.891 | - 5.619 | 0.764 |
| L-9 x Sd 63 | 3.276** | 5.156 | - 0.850 | 4.266 | 0.256 | -0.754 |
| L-10 x Sd 63 | -1.113 | - 0.789 | - 2.850** | - 9.797* | 18.256** | -4.061* |
| L-11 x Sd 63 | 2.821* | - 3.292 | - 1.038* | 4.453 | 0.506 | 9.514** |
| L-12 x Sd 63 | -2.706* | 6.274 | - 1.100* | - 1.922 | - 2.631 | -1.023 |
| L-13 x Sd 63 | -1.323 | - 3.499 | - 0.413 | - 2.109 | 7.319* | -1.267 |
| L-14 x Sd 63 | -1.441 | 0.759 | 2.150** | 8.703* | 11.494** | 1.652 |
| L-15 x Sd 63 | -2.089 | -14.057** | - 0.038 | - 0.172 | 2.381 | 2.364 |
| L-16 x Sd 63 | -6.246** | - 4.652 | - 0.850 | -19.797** | - 16.944** | -3.067 |
| L-17 x Sd 63 | -2.328* | - 6.034 | - 0.600 | -12.297** | 9.069** | 0.346 |
| L-18 x Sd 63 | -3.527** | - 8.217* | - 0.038 | - 9.422* | 6.381* | -2.692 |
| L-19 x Sd 63 | 0.817 | -11.172** | - 0.725 | - 5.547 | 6.256* | 4.183* |
| L-20 x Sd 63 | 1.576 | 6.007 | - 1.788** | - 1.172 | 1.131 | -2.986 |
| SE | | | | | | |
| $\hat{S}_{ij}$ | 1.163 | 4.073 | 0.455 | 3.957 | 2.953 | 1.891 |
| $\hat{S}_{ij} - \hat{S}_{Kl}$ | 1.645 | 5.760 | 0.644 | 5.597 | 4.147 | 2.674 |

*,** Indicate significant differences at 0.05 and 0.01 levels of probability, respectively.

Resistance to late wilt disease of the female line L-13 across the two testers, in addition to three lines crossed with Sd 63 (L-7, L-9 and L-11) were equal to the best commercial hybrid SC 10 (100 %). Meanwhile, resistance of the above mentioned lines, in addition to the tested line L-7 over the two testers was insignificantly higher than the white check hybrid SC 122 (99.5%). General combining ability effects (Table 3) showed that lines L-7, L-9, L-12 and L-13 had the best significant GCA effects for late wilt resistance, suggesting that these lines are good donor for resistance to this disease. Considering SCA effects (Table 4), the highest desirable SCA effects towards resistance resulted from the testcrosses L-10 x Sd 7, L-11 x Sd 63 and L-19 x Sd 63 which showed significantly positive values. The two testers were significantly different in their reaction to late wilt disease (Table 1) and the inbred tester Sd 63 across the 20 lines was significantly more resistant to late wilt (97.5 %) than the inbred tester Sd 7 (95.0 %). This was reflected by GCA effects of 1.267** and –1.267** for the two testers, respectively. These results agree with those of Salama *et al.* (1995) and Sadek *et al.* (2000).

Data obtained (Table 2) showed that resistance to late wilt disease ranged from 78.4 to 100 % (with range of 21.6 %) for crosses with Sd 7. Resistance to late wilt, however, ranged from 93.8 to 100% (with range of 6.2 %) for crosses with Sd 63. Variation in resistance among testcrosses with Sd 7 was greater than that of testcrosses with Sd 36. This result indicates that the lower resistance inbred tester (Sd 7) which might have a low gene frequency for resistance was better in differentiating among lines. On the contrary, deleterious (susceptibility) genes in the lines were masked in topcrosses by the dominant genes of the more resistant inbred tester (Sd 63). These results are in accordance with Rawlings and Thompson (1962), El-Itriby *et al.* (1990)a and Soliman *et al.* (2001) who concluded that narrow genetic base testers can be effectively used to identify lines having good GCA and the most efficient tester is the one having a low frequency of favorable alleles.

The estimates of combining ability variances (k2 G.C.A. and k2 S.C.A.) and its interaction with locations (k2 G.C.A. x loc and k2 S.C.A. x loc) for grain yield, late wilt resistance and other studied traits (Table 5) showed that sca variance played the major role in determining the inheritance of all traits. This indicates that the largest part of the total genetic variability associated with these traits was the result of non-additive gene action. Similar findings were also obtained by Dhillon and Singh (1977), Singh and Asnani (1979), Landi *et al.* (1986) and Sadek *et al.* (2000) who reported that SCA or non-additive gene action was predominant and played an important role in the inheritance of grain yield, silking date, plant and ear height. Also Shehata and Dahawan (1975), and El-Zeir *et al.* (2000) demonstrated that variance due to dominance genes was more important than variance due to additive genes for grain yield. For late wilt, Shehata (1976), El-Itriby *et al.* (1990), Sadek *et al.* (2000) and Soliman *et al.* (2001) found that sca variance was more important in conditioning resistance than gca variance. Furthermore, the non-additive gene action (dominance and epistasis) interacted more with the different environmental conditions prevailing in the two locations than the additive gene effects for grain yield, silking date and ear height. The opposite, however was true for number of ears/100 plants, plant height and late wilt resistance (Table 5). This finding indicates non-additive types of gene action to be more affected by environment than addictive and addictive x addictive type of gene action for grain yield, days to mid silking and ear height and the opposite was true for number of ears/plant, plant height and late wilt resistance. This result is in agreement with the findings of several investigators who reported specific combining ability to be more sensitive to environmental changes than general combining ability (Gilbart, 1958). Shehata and Dahwan (1975) and Sadek *et al.*(2000), also found that the non-additive genetic variation interacted more with the environment than the additive component. On the other hand, El-Itriby *et al.* (1990), El-Zeir *et al.* (2000) and Soliman *et al.* (2001) reported that the additive type of gene action were more affected by environment than non-additive ones.

Table (5): Estimates of general ($k^2$ G.C.A. and specific ($k^2$ S.C.A.) combining ability effects and their interaction with locations for grain yield and other traits.

| Estimates | Grain yield | No of ears/100 plant | Days to 50% silking | Plant height | Ear height | L.W. resistance |
|---|---|---|---|---|---|---|
| $k^2$ G.C.A. | 8.740 | 32.774 | 2.509 | - 5.107 | - 14.711 | 0.933 |
| $k^2$ S.C.A. | 16.496 | 119.088 | 2.831 | 197.225 | 149.575 | 15.659 |
| $k^2$ GCA x loc. | 7.394 | 42.213 | -0.072 | 2.469 | 21.187 | 1.772 |
| $k^2$ SCA x loc. | 14.538 | 31.475 | 0.830 | - 7.825 | 39.775 | 0.949 |

Negative estimates are considered equal to zero (Robinson *et al.*(1955).

The study suggested that six topcrosses (L-4 x Sd 7, L-13 x Sd 7, L-14 x Sd 7, L-16 x Sd 7, L- 17 x Sd 7 and L-18 x Sd 7) should be tested further for commercial use. Moreover, the six inbreds included in these crosses (L-4, L-13, L-14, L-16, L-17 and L-18), in addition to the parental lines L-7, L-9 and L-11 had good GCA effects for yield, earliness and late wilt resistance (Table 3). These inbreds should be interamated to form a new synthetic variety of white maize, which can be used as a base population for the extraction of more favorable white lines for the development of high yielding earlier and disease resistant single cross hybrids of white maize

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# تحليل الهجن القمية لانتخاب سلالات الذرة الشامية في الأجيال المبكرة

**صادق الشحات صادق ، محمد محمد سليمان ، عفيفي عبد المعبود بركات ، خميس إبراهيم خليفه**

**برنامج بحوث الذرة الشامية – معهد بحوث المحاصيل الحقلية– مركز البحوث الزراعية**

## الملخص العربى

في موسم ١٩٩٩ تم التهجين القمي لعدد ٢٠ سلاله بيضاء الحبوب من الذرة الشامية مستنبطة في الجيل الثالث من المجتمع التركيبي - ٥ ( الحلقة الثالثة) مع السلالتين التجاريتين الكشافتين سدس ٧ وسدس ٦٣. تم تقييم الـ ٤٠ هجيناً قمياً الناتجة في تجارب مكررة تم تنفيذها فى محطتي البحوث الزراعية بالجميزة وسدس خلال موسم النمو ٢٠٠٠. وقيمت الهجن القمية الناتجة لصفات محصول الحبوب ، عدد الكيزان/١٠٠ نبات ، ميعاد ظهور الحريرة ، ارتفاع النبات ، ارتفاع الكوز ، المقاومة لمرض الذبول المتأخر. ويمكن تلخيص أهم النتائج كما يلى :-

وجد أن التباين بين السلالات الكشافة كان أكبر من التباين بين السلالات المختبرة كما كان تباين السلالات الكشافة أكثر تأثراً بالظروف البيئية من السلالات المختبرة. وقد رتبت السلالات الكشافة السلالات المختبرة بصورة مختلفة. كانت السلالات الأبوية أرقام ٤ ، ٩ ، ١١ ، ١٣ ، ١٤ ، ١٧ ، ١٩ ، ٢٠ أحسن السلالات بالنسبة للمحصول حيث أظهرت تقديرات موجبة ومعنوية للقدرة العامة على التآلف لصفة محصول الحبوب وكذلك كانت القدرة العامة على التآلف للسلالات أرقام ١١ ، ١٣ ، ١٤ ، ١٥ ، ١٩ موجبة ومعنوية لصفة عدد الكيزان وللسلالات أرقام ٧، ٩، ١٢، ١٣ أيضاً موجبة ومعنوية لصفة المقاومة لمرض الذبول المتأخر بينما بالنسبة لصفة التزهير فإن السلالات الأبوية أرقام ١١ ، ١٣ ، ١٥، ١٦، ١٧ ، ١٨، ١٩ ، ٢٠ وكذلك السلالات أرقام ٢، ٧، ١٥ بالنسبة لصفتي ارتفاع النبات والكوز أظهرت تأثيرات سالبة ومعنوية أي مرغوبة (اتجاه التبكير واتجاه قصر النبات وموقع الكوز المنخفض على التوالي) للقدرة العامة على التآلف. لذلك توصى الدراسة باستخدام السلالات الأبوية أرقام ٤، ٧

، ٩، ١١، ١٣، ١٤، ١٦، ١٧، ١٨ في برنامج التربية للهجن عالية المحصول مبكرة النضج مع المقاومة العالية لمرض الذبول المتأخر وكذلك استعمالها في تكوين مجتمع وراثي جديد يخدم برنامج عزل السلالات. هذا وقد أعطت السلالة الكشافة سدس ٧ أعلى محصول بالنسبة لهجنها الاختبارية إذا ما قورنت بالسلالة الكشافة سدس ٦٣ . قد أظهرت النتائج أن السلاله الكشافة سدس ٧ عند تهجينها مع السلالات أرقام ١٧، ١٦، ١٤ أعطت ثلاث هجن فردية فاقت معنوياً أحسن الهجن التجارية هـ.ف ١٠ (٢٩,٦٨ إردب/فدان) بمقدار ٦,٧ ، ٤,٩ ، ٤,١ أردب/فدان على التوالي. بالإضافة لذلك فأن الهجن الإختبارية السالفة الذكر (سلاله ١٦ × سدس ٧ ، سلاله ١٧ × سدس ٧) أظهرنا تأثيرات موجبة ومعنوية للقدرة الخاصة على التآلف لصفة محصول الحبوب. أعطى عدد ١٠ هجن قمية من جملة الـ٤٠ هجيناً المختبرة قدرة خاصة على التآلف عالية ومعنوية لصفة المحصول العالى. كما أظهر ٦ ، ٣ هجن قمية تقديرات موجبة ومعنوية للقدرة الخاصة على التآلف بالنسبة لصفة تعدد الكيزان والمقاومة لمرض الذبول المتأخر على التوالي . في حين أنه أظهرت تسعة هجن تفوقا معنويا في القدرة الخاصة على التآلف لصفة التبكير .

أظهر التأثيرالراجع للفعل الوراثي الغير مضيف دورا أكثر أهمية بالمقارنة بالتأثير الراجع للفعل الوراثي المضيف فى وراثة جميع الصفات تحت الدراسة . وبالإضافة لذلك كان التفاعل بين التأثير الغير مضيف والبيئة أعلى من التفاعل بين التأثير المضيف والبيئة بالنسبة لصفة المحصول وميعاد ظهور الحريرة وارتفاع الكوز بينما كان الأخير أعلى بالنسبة للثلاث صفات الأخرى .