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# DIALLEL CROSS ANALYSIS FOR SOME QUANTITATIVE TRAITS IN YELLOW MAIZE UNDER STRESS AND NORMAL IRRIGATION TREATMENTS

# I. BIOCHEMICAL GENETIC MARKERS FOR HETEROSIS AND COMBINING ABILITY

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## ABSTRACT

*5X5 half diallel cross along with their parental maize inbred lines were evaluated under normal and drought environments. The obtained data revealed highly significant differences between environments for all studied traits. Partitioning of genetic variations of crosses into parents and their hybrids showed that variance due to general combining ability (GCA) was significant for all studied traits under both environments and for their combined analysis except for ear length under normal environments and the combined analysis and 100 kernels weight under drought. Variance due to specific combining ability (SCA) was significant for all studied traits under both environments and their combined analysis except for number of rows/ear under both environments and their combined data and 100-kernels weight for the combined analysis. The ratio of GCA/SCA revealed that the largest part of the total genetic variability was mainly due to non-additive gene action for most of the studied traits under normal and drought environments. Mean squares due to the interaction between each of GCA and SCA with environments were highly significant for all studied traits except for ear length, ear diameter, number of kernels per row and 100-kernels weight for GCA x environment and number of rows per ear for SCA x environment indicating that, both additive and non-additive gene effects were influenced by environments. The best general combiners for grain yield per plant and two or more of its attributes were the inbred lines P1 and P4 under normal conditions and P3 under drought conditions. Six out of ten crosses under normal conditions and three crosses under drought conditions showed positive and significant SCA effects for grain yield per plant and two or more of its attributes. In this regard, the best* $F_1$ *cross was P1 x P4 under both normal and drought conditions. The electrophoretic patterns (SDS-PAGE) for water soluble proteins of the five maize inbred lines and their ten* $F_1$ *hybrids showed that, the electrophoretic bands could be a useful tool for the identification and characterization of the used five inbred lines of yellow maize. Using soluble leaves protein electrophoresis could be effective in the identification of the highly heterotic hybrids and those having high specific combining ability effects under drought conditions as biochemical genetic markers associated with hybrid vigor and specific combining ability in yellow maize hybrids.*

Key words: ***Diallel cross, Yellow maize, Water stress, Heterosis, Combining ability, Susceptibility index, Electrophoretic patterns.***

## INTRODUCTION

Drought, like many other environmental stresses, has adverse affects on crop yield. Low water availability is one of the major causes for crop yield reductions affecting the majority of the farmed regions around the world. As water resources for agronomic uses become more limiting, the development of drought-tolerant lines becomes increasingly more important (*Bruce et al 2002*). It has been observed that grain yield is significantly reduced when plants are grown under water shortage (*Hall et al 1981, Quattar et al 1987, Sobrado 1990, Attia et al 1994, El-Ganayni et al 2000 and Yadav et al 2003). Maize breeders were deeply involved during the last years, in attempts to improve high yielding cultivars under drought stress environments (Edmeades et al 1992,Saneoka et al 1996,Abd El-Saboor 1997 and Younis and Aref 2001).*

Information on the relative importance of general combining ability (GCA) and specific combining ability (SCA) are essential for breeding maize to tolerate drought stress conditions. Generally, GCA is associated with additive genes while SCA is attributed primarily to non-additive (dominance and epistasis) genes. It is very essential that, the breeder should evaluate the potentialities of the available germplasm for new recombinations and eventually combining ability which have proved to be of considerable use in breeding crop plants. In this regard, several studies have been reported in maize (Desai and Singh 2001, Abd El-Aty and Katta 2002, Shafey *et al* 2003 and El-Morshidy *et al* 2003). Several investigators tried to identify and characterise maize inbreds via proteins electrophoresis (Ohms 1985 and Abd El-Tawab *et al* 1989 ,2001).

Therefore, this investigation aims at studying (1) the magnitude of heterosis and combining ability under normal and water stress conditions in ten maize hybrids and their parents, and (2) the efficiency of protein electrophoresis in the identification and characterization of the five maize inbred lines and their hybrids for heterosis and combining ability under drought conditions using SDS-PAGE for soluble protein patterns.

## MATERIALS AND METHODS

The genetic material used in this investigation included new five yellow maize (*Zea mays* L.) lines (AY1, AY2, AY3, AY4 and AY5), representing a wide range of diversity for several agronomic characters and drought resistance. These lines were developed by the first author through the breeding program at Dept. of Genetic and Cytology, National Research Center. These lines were derived from single cross (S.C.)150 ,S.C.151, S.C.158,three way cross (T.W.C.)352 and double cross (D.C.) Dahab x Sabeiny.

In 2003 season, all possible cross combinations excluding reciprocals were made among the five inbred lines giving a total of 10 crosses. In 2004 season, the five parents and their ten crosses were evaluated under two moisture regimes at the Experimental Farm of the National Research Center, at Shalakan, Kalubia Governorate ,Egypt. The first moisture regime was the normal (full) irrigation as it is carried out for this crop in the area (experiment I) and the second was made by withholding irrigation after 2$^{nd}$ irrigation for three successive irrigations (experiment II).

Each experiment was conducted in a randomized complete block design with three replications. The experimental plot included three rows of five meters long and 70 cm wide. Planting was in hills spaced at 25 cm apart .The common agricultural practices of growing maize were applied properly as recommended in the district. At harvest plant height, ear height, ear length, ear diameter, number of rows / ear, number of kernels / row, 100-grain weight and grain yield per plant were recorded on a sample of 10 guarded plants in the middle row of each plot. The drought susceptibility index (s) was used to characterize the relative stress resistance of all genotypes. The susceptibility indices were calculated independently using original data for yield and some yield components using a generalized formula (*Fischer and Maurer1978*) as follows:

$S = (1 - Yd / Yp) / D$ ,Where

S = An index of drought susceptibility

Yd = Performance of a genotype under drought stress.

Yp = Performance of the same genotype under normal irrigation.

D = Drought intensity = 1 – (mean Yd of all genotypes / mean Yp of all genotypes).

The data obtained for drought susceptibility index values for each trait were analyzed on an individual plant basis. An ordinary analysis of variance for each water regime, and the combined analysis over both regimes were performed according to Snedecor and Cochran (1981). General and specific combining ability variances and effects were obtained by employing Griffing's (1956) diallel cross analysis method 2 model I .

In the protein electrophoretical study; two leaves of each of the five parents and their10 F's were used for SDS-protein analysis. Sodium dodecylsulphate polyacrylamide gel electrophoresis (SDS-PAGE) was performed on water soluble protein fractions (albumin and globulin) according to the method of Laemmli (1970) as modified by Studier (1973). The SDS-protein gel was scanned and analyzed using Gel Doc 2000 BioRad System.

## RESULTS AND DISCUSSION

### Analysis of variance

Mean square estimates for all studied traits under normal, water stress and for combined data across them are shown in Table (1). Highly significant differences between environments were found for all studied traits. Mean squares due to genotypes, parents and crosses were also significant for all recorded traits under normal and water stress environments and their for combined data except ear length, ear diameter, number of rows per ear and 100 kernels weight for parents and number of rows per ear and number of kernels per row for crosses under normal environments. Parents versus crosses mean squares were significant for all traits under all environments except ear length ,ear height and number of rows per ear under drought environments which were insignificant.

The mean squares due to interaction of genotypes with the two environments were highly significant for all studied traits except ear diameter and number of rows per ear which were insignificant, indicating different responses of these genotypes from normal to stress conditions. The partitioning of crosses mean squares into those due to parents and those due to F 's showed that variance due to general combining ability (GCA) was significant for all studied traits under both environments and for their combined data except for ear length under normal environments and for the combined and 100 kernels weight under drought environments. Variance due to specific combining ability (SCA) was also significant for all studied traits under both environments and for their combined data except number of rows/ear under both environments and for their combined data and 100-kernels weight in the combined analysis. The ratio of GCA / SCA was less than unity for all studied traits under both environments and for their combined except ear height and number of rows per ear for both environments and their combined data, ear length and number of kernels per row under drought environments and plant height and number of kernels per row in combined analysis which were more than unity. These findings indicates that the largest part of the total genetic variability is due to non-additive gene action for the majority of the studied traits. These results are in agreement with those reported by El-Hosary *et al* 1990, Mostafa *et al* 1996, El-Morshidy *et al* 2003 and Shafey *et al* 2003.

**Table 1. Mean squares estimates for all studied traits in 5 x 5 yellow maize diallel crosses under normal and drought environments (Env.) as well as for combined data.**

| S.O.V. | Env. | Df | Plant height cm | Ear height cm | Ear length cm | Ear diameter cm | No. of Rows / ear | No. of Kernels / row | 100 kernels weight g | Grain yield/ plant g |
|---|---|---|---|---|---|---|---|---|---|---|
| Env. | Combined | 1 | 100935.51** | 27144.10** | 203.10** | 7.57** | 51.38** | 751.11* | 1095.51** | 111021.34** |
| Reps./ Env. | Normal | 2 | 72.96 | 67.20 | 0.58 | 0.02 | 0.96 | 5.36 | 11.09 | 41.36 |
| | Drought | 2 | 68.62 | 110.07 | 1.08 | 0.03 | 0.16 | 12.69 | 2.02 | 18.02 |
| | Combined | 4 | 65.51 | 88.63 | 0.83 | 0.02 | 0.56 | 9.02 | 6.56 | 22.68 |
| Genotypes (G.) | Normal | 14 | 3099.84** | 998.94* | 2.88* | 0.25** | 3.59* | 50.33** | 55.02** | 2019.60** |
| | Drought | 14 | 2717.64** | 420.63** | 3.59** | 0.63** | 3.40** | 45.15** | 28.63** | 616.14** |
| | Combined | 14 | 2241.26** | 863.50** | 4.01** | 0.73** | 5.12** | 73.49** | 72.09** | 2149.76** |
| Parents (P) | Normal | 4 | 2655.83** | 1154.17** | 1.69 | 0.21 | 3.77 | 50.43* | 12.10 | 1147.90** |
| | Drought | 4 | 4579.17** | 829.17** | 6.48* | 0.54* | 6.43* | 48.90* | 16.90* | 336.50 |
| | Combined | 4 | 4607.08** | 1881.25** | 5.53* | 0.50* | 7.00** | 85.03** | 25.47* | 757.87** |
| Crosses (C.) | Normal | 9 | 1204.54** | 278.24** | 2.91* | 0.25* | 2.95 | 28.46 | 30.83** | 955.78** |
| | Drought | 9 | 1080.40** | 272.93** | 2.53* | 0.50** | 2.08* | 34.89** | 16.48** | 361.47** |
| | Combined | 9 | 1310.45** | 218.30** | 2.90** | 0.66** | 3.60* | 36.70** | 34.01** | 1079.91** |
| P. Vs. C. | Normal | 1 | 21933.62** | 6864.40** | 7.40* | 0.48* | 8.71* | 246.68** | 444.44** | 15080.28** |
| | Drought | 1 | 10006.68** | 115.60 | 1.63 | 2.21** | 3.21 | 122.5** | 184.9** | 4026.71** |
| | Combined | 1 | 1155.20** | 2599.20** | 7.99** | 2.37** | 11.25** | 358.42** | 601.34** | 17346.05** |
| G. x Env. | Combined | 14 | 3576.23** | 556.08** | 2.46* | 0.15 | 1.88 | 21.99* | 11.56** | 485.94** |
| P. x Env. | Combined | 4 | 2627.92** | 102.08 | 2.63 | 0.26 | 3.20 | 14.30 | 3.53 | 726.53** |
| C. x Env. | Combined | 9 | 974.49** | 332.88** | 2.54* | 0.09 | 1.42 | 26.66* | 13.30** | 237.34** |
| P. vs. C. x Env. | Combined | 1 | 30785.09** | 4380.81** | 1.05 | 0.31 | 0.67 | 10.76 | 28.01* | 1760.95** |
| GCA | Normal | 4 | 2910.36** | 1354.09** | 0.49 | 0.24* | 8.68** | 45.13** | 32.92** | 1369.39** |
| | Drought | 4 | 2090.13** | 481.46** | 3.67* | 0.30* | 9.06** | 80.01** | 8.84 | 327.77** |
| | Combined | 4 | 3987.60** | 1630.69** | 1.95 | 0.48** | 13.45** | 110.53** | 35.87** | 904.33** |
| SCA | Normal | 10 | 3175.64** | 856.89** | 3.84** | 0.26** | 1.56 | 52.41** | 63.86** | 2279.64** |
| | Drought | 10 | 2968.64** | 396.30** | 3.56** | 0.77** | 1.14 | 31.21** | 36.54** | 731.48** |
| | Combined | 10 | 1542.72** | 556.62** | 4.84** | 0.84** | 1.79 | 58.67** | 86.58 | 2647.93** |
| GCA x Env. | Combined | 4 | 1012.88** | 204.86** | 2.21 | 0.06 | 4.29** | 14.61 | 5.89 | 792.83** |
| SCA x Env. | Combined | 10 | 4601.56** | 696.56** | 2.56* | 0.19* | 0.91 | 24.95* | 13.83** | 363.18** |
| Error | Normal | 28 | 50.81 | 57.27 | 1.11 | 0.08 | 1.60 | 12.93 | 4.78 | 86.80 |
| | Drought | 28 | 43.98 | 43.42 | 1.07 | 0.09 | 1.07 | 8.21 | 4.12 | 61.23 |
| | Combined | 56 | 47.40 | 50.35 | 1.09 | 0.09 | 1.33 | 10.57 | 4.44 | 74.01 |
| GCA/SCA | Normal | | 0.92 | 1.58 | 0.13 | 0.92 | 5.56 | 0.86 | 0.52 | 0.60 |
| | Drought | | 0.70 | 1.22 | 1.03 | 0.39 | 7.95 | 2.56 | 0.24 | 0.45 |
| | Combined | | 2.58 | 2.93 | 0.40 | 0.57 | 7.51 | 1.88 | 0.41 | 0.31 |

***,** indicate significant at 0.05 and 0.01 probability levels, respectively.**

Highly significant mean squares due to general combining ability X environment and specific combining ability X environment were detected for all studied traits except ear length ,ear diameter, number of kernels per row and 100 kernels weight for GCA X environment and number of rows per ear for SCA X environment, indicating that both additive and non-additive gene effects were influenced by environments.

## Mean performance, heterosis over better parent and susceptibility index

Mean performance for all studied traits under normal and drought conditions as well as combined data are presented in Table (2). Mean values for these traits exhibited the parental diversity and the genotypes differential response from normal to drought conditions. Regarding to grain yield per plant; inbred line-1 ranked the first as the best under normal conditions

Table 2. Mean performance for all studied traits in 5 x 5 yellow maize diallel cross under normal and drought conditions as well as combined data.

| Genotypes | Env. | Plant height cm | Ear height cm | Ear length cm | Ear diameter cm | No. of rows/ ear | No. of kernels/ row | 100 kernels weight g | Grain yield/ plant g |
|---|---|---|---|---|---|---|---|---|---|
| inbred | Normal | 183.33 | 95.00 | 16.33 | 4.67 | 13.00 | 31.00 | 28.00 | 160.00 |
| line P1 | Drought | 168.33 | 85.00 | 12.83 | 3.50 | 9.67 | 22.67 | 20.67 | 71.67 |
| Ay1 | Combined | 175.83 | 90.00 | 14.58 | 4.08 | 11.33 | 26.83 | 24.33 | 115.83 |
| P1 x P2 | Normal | 221.67 | 120.00 | 15.50 | 4.23 | 14.33 | 34.67 | 32.00 | 154.33 |
|  | Drought | 140.00 | 80.00 | 13.33 | 3.60 | 12.00 | 25.33 | 29.00 | 90.00 |
|  | Combined | 180.83 | 100.00 | 14.42 | 3.92 | 13.17 | 30.00 | 30.50 | 122.17 |
| P1 x P3 | Normal | 265.00 | 141.67 | 17.83 | 4.33 | 15.00 | 36.00 | 36.67 | 150.00 |
|  | Drought | 126.67 | 80.00 | 14.83 | 4.13 | 13.00 | 32.33 | 31.33 | 88.67 |
|  | Combined | 195.83 | 110.83 | 16.33 | 4.23 | 14.00 | 34.17 | 34.00 | 119.33 |
| P1 x P4 | Normal | 206.67 | 118.33 | 18.50 | 4.93 | 13.33 | 39.33 | 41.33 | 211.67 |
|  | Drought | 128.33 | 82.00 | 12.50 | 4.57 | 11.67 | 23.33 | 31.33 | 108.33 |
|  | Combined | 167.50 | 100.17 | 15.50 | 4.75 | 12.50 | 31.33 | 36.33 | 160.00 |
| P1 x P5 | Normal | 223.33 | 121.00 | 17.00 | 4.73 | 13.67 | 27.67 | 40.00 | 155.00 |
|  | Drought | 136.67 | 86.00 | 13.33 | 4.67 | 11.33 | 25.33 | 28.33 | 66.00 |
|  | Combined | 180.00 | 103.50 | 15.17 | 4.70 | 12.50 | 26.50 | 34.17 | 110.50 |
| inbred | Normal | 158.33 | 85.00 | 17.50 | 4.33 | 12.33 | 34.33 | 26.33 | 121.00 |
| line P2 | Drought | 210.00 | 80.00 | 15.00 | 4.00 | 13.00 | 30.00 | 23.00 | 80.00 |
| Ay2 | Combined | 184.17 | 82.50 | 16.25 | 4.17 | 12.67 | 32.17 | 24.67 | 100.50 |
| P2 x P3 | Normal | 250.00 | 141.67 | 17.50 | 4.53 | 14.67 | 32.33 | 34.67 | 170.00 |
|  | Drought | 143.33 | 77.33 | 13.17 | 3.87 | 13.67 | 30.00 | 26.33 | 93.33 |
|  | Combined | 196.67 | 109.50 | 15.33 | 4.20 | 14.17 | 31.17 | 30.50 | 131.67 |
| P2 x P4 | Normal | 271.67 | 139.33 | 17.33 | 4.03 | 13.67 | 36.00 | 32.00 | 161.00 |
|  | Drought | 153.33 | 80.67 | 14.83 | 3.43 | 11.33 | 32.67 | 27.67 | 95.67 |
|  | Combined | 212.50 | 110.00 | 16.08 | 3.73 | 12.50 | 34.33 | 29.83 | 128.33 |
| P2 x P5 | Normal | 243.33 | 131.00 | 17.00 | 4.20 | 12.00 | 33.00 | 35.33 | 164.33 |
|  | Drought | 163.33 | 91.67 | 14.00 | 3.53 | 12.67 | 26.00 | 24.33 | 93.33 |
|  | Combined | 203.33 | 111.33 | 15.50 | 3.87 | 12.33 | 29.50 | 29.83 | 128.83 |
| inbred | Normal | 240.00 | 133.33 | 15.83 | 4.13 | 14.67 | 30.67 | 28.00 | 123.33 |
| line P3 | Drought | 230.00 | 118.33 | 14.00 | 3.83 | 13.00 | 25.67 | 21.67 | 85.00 |
| Ay3 | Combined | 235.00 | 125.83 | 14.92 | 3.98 | 13.83 | 28.17 | 24.83 | 104.17 |
| P3 x P4 | Normal | 251.67 | 142.67 | 15.33 | 4.77 | 14.67 | 36.00 | 34.33 | 172.67 |
|  | Drought | 148.33 | 88.00 | 13.67 | 3.93 | 12.00 | 31.00 | 25.33 | 94.67 |
|  | Combined | 200.00 | 115.33 | 14.50 | 4.35 | 13.33 | 33.50 | 29.83 | 133.67 |
| P3 x P5 | Normal | 245.00 | 129.67 | 17.60 | 4.57 | 13.67 | 33.33 | 32.33 | 165.00 |
|  | Drought | 152.00 | 90.33 | 14.20 | 3.93 | 12.33 | 28.33 | 26.67 | 89.00 |
|  | Combined | 198.50 | 110.00 | 15.90 | 4.25 | 13.00 | 30.83 | 29.50 | 127.00 |
| inbred | Normal | 200.00 | 116.67 | 15.67 | 4.10 | 12.00 | 24.67 | 31.33 | 136.00 |
| line P4 | Drought | 156.67 | 90.00 | 14.50 | 3.00 | 10.67 | 24.67 | 26.00 | 62.67 |
| Ay4 | Combined | 178.33 | 103.33 | 15.08 | 3.55 | 11.33 | 24.67 | 28.67 | 99.33 |
| P4 x P5 | Normal | 236.67 | 126.67 | 17.33 | 4.33 | 12.33 | 33.33 | 36.00 | 181.67 |
|  | Drought | 191.67 | 110.00 | 15.50 | 4.03 | 11.00 | 24.67 | 26.67 | 101.67 |
|  | Combined | 214.17 | 118.33 | 16.42 | 4.18 | 11.67 | 29.00 | 31.33 | 141.67 |
| inbred | Normal | 191.67 | 95.00 | 15.83 | 4.00 | 12.00 | 25.33 | 30.33 | 108.33 |
| line P5 | Drought | 135.00 | 76.67 | 11.33 | 3.17 | 11.33 | 19.00 | 25.67 | 60.67 |
| Ay5 | Combined | 163.33 | 85.83 | 13.58 | 3.58 | 11.67 | 22.17 | 28.00 | 84.50 |
| LSD | Normal | 11.92 | 12.66 | 1.76 | 0.48 | 2.11 | 6.01 | 3.66 | 15.58 |
| 0.05 | Drought | 11.09 | 11.02 | 1.73 | 0.52 | 1.73 | 4.79 | 3.39 | 13.09 |
|  | Combined | 7.96 | 8.21 | 1.21 | 0.35 | 1.33 | 3.76 | 2.44 | 9.95 |
| LSD | Normal | 17.34 | 18.42 | 2.56 | 0.70 | 3.07 | 8.74 | 5.33 | 22.67 |
| 0.01 | Drought | 16.14 | 16.03 | 2.52 | 0.76 | 2.52 | 6.97 | 4.93 | 19.04 |
|  | Combined | 10.93 | 11.27 | 1.66 | 0.48 | 1.83 | 5.16 | 3.35 | 13.66 |

while inbred line-3 was the best under drought conditions. The hybrid P1 x P4 was the best in grain yield under normal and drought environments. The hybrids P2 x P3, P2 x P5, P3 x P5, P4 x P5 and P1 x P4 under normal conditions and the hybrids P1 x P4 and P4 x P5 under drought conditions, respectively exceeded their better parents for yielding ability (Table 3). It is also clear from Table (3) that the best hybrids under normal conditions were P2 x P4 for plant height, P1 x P4 for ear length, number of kernels per row

**Table 3. Percentage of heterosis over better parent for all studied traits under normal and Drought conditions.**

| Genotype | Env. | Plant height cm | Ear Height cm | Ear Length cm | Ear Diameter cm | No. of rows / ear | No. of kernels/ row | 100 kerneles weight g | Grain yield/ plant g |
|---|---|---|---|---|---|---|---|---|---|
| P1 x P2 | Normal | 20.91** | 26.32** | -11.43* | -9.29 | 10.26 | 0.97 | 14.29* | -3.54 |
| | Drought | -32.80** | -5.88 | -14.89 | -13.60 | -5.26 | -8.43* | 29.85** | 12.50 |
| P1 x P3 | Normal | 10.42** | 6.25 | 9.18 | -7.14 | 2.27 | 16.13 | 30.95** | -6.25 |
| | Drought | -44.93** | -32.39** | 5.95 | 7.83 | 0.00 | 25.97** | 44.62** | 4.31 |
| P1 x P4 | Normal | 3.33 | 1.43 | 13.27* | 5.71 | 2.56 | 26.88** | 31.92** | 32.29** |
| | Drought | -23.76** | -8.89 | -13.79* | 30.48** | 9.38 | -5.41 | 20.51** | 51.16** |
| P1 x P5 | Normal | 16.52** | 27.37** | 4.08 | 1.43** | 5.13 | -10.75 | 31.87** | -3.13 |
| | Drought | -18.81** | 1.18 | 3.90 | 33.33** | 0.00 | 11.77 | 10.39 | -7.91 |
| P2 x P3 | Normal | 4.17 | 6.25 | 0.00 | 4.62 | 0.00 | -5.83 | 23.81** | 37.84** |
| | Drought | -37.68** | -34.65** | -15.96* | -7.20 | 5.13 | 8.43 | 17.91 | 9.80 |
| P2 x P4 | Normal | 35.83** | 19.43** | -0.95 | -6.92 | 10.81 | 4.85 | 2.13 | 18.38** |
| | Drought | -26.40** | -10.37 | -5.32 | -17.60* | -10.53* | 18.07 | 6.41 | 19.58** |
| P2 x P5 | Normal | 26.96** | 37.90** | -2.86 | -3.08 | -2.70 | -3.88 | 16.48** | 35.81** |
| | Drought | -21.60** | 14.58* | -10.64 | -15.20 | 0.00 | -6.02 | -5.20 | 16.66* |
| P3 x P4 | Normal | 4.86* | 7.00 | -3.16 | 15.32* | 0.00 | 17.39 | 9.57 | 26.96** |
| | Drought | -35.51** | -25.63** | -5.75 | 2.61 | -7.70 | 20.78* | -2.56 | 11.37 |
| P3 x P5 | Normal | 2.08 | -2.75 | 11.16* | 10.48 | -6.82 | 8.70 | 6.60 | 33.78** |
| | Drought | -33.91** | -23.66** | 1.43 | 2.61 | -5.13 | 10.39 | 3.90 | 4.71 |
| P4 x P5 | Normal | 18.33** | 8.57 | 9.47* | 5.69 | 2.78 | 31.58** | 14.90** | 33.58** |
| | Drought | 22.34** | 22.22** | 6.90 | 27.37** | -2.94 | 0.00 | 2.56 | 62.23** |

***,** indicate significant at 0.05 and 0.01 probability levels, respectively.**

and 100 kernels weight, P3 x P4 for ear diameter and ear height and P1 x P3 for number of rows per ear. The best hybrids under drought conditions were P4 x P5 for plant height , ear length and ear height, P1 x P5 for ear diameter, , P2 x P3 for number of rows per ear, P2 x P4 for number of kernels per row and P1 x P3 for 100 kernels weight.

Stress susceptibility index "S" was used to estimate the relative stress injury because it accounted for variation in yield potential and stress intensity. Low stress susceptibility (S < 1) is synonymous with higher stress tolerance (Fischer and Maurer 1978). The results indicated that S values (Table 4) varied between parents and their F1 crosses for all studied traits.P3, P2, P2 x P4, P1 x P3 and P1 x P2 were the best drought tolerant genotypes for grain yield per plant and one or more of its attributes.

**Table 4. Stress susceptibility index (S) of the fifteen genotypes for grain yield and its components.**

| Genotypes | No. of rows / ear | No. of kernels / row | 100 kernels weight g | Grain yield/ Plant g |
|---|---|---|---|---|
| P1 | 2.28 | 1.51 | 1.25 | 1.22 |
| P1 x P2 | 1.45 | 1.52 | 0.45 | 0.92 |
| P1 x P3 | 1.19 | 0.57 | 0.70 | 0.91 |
| P1 x P4 | 1.11 | 2.29 | 1.15 | 1.08 |
| P1 x P5 | 1.52 | 0.48 | 1.39 | 1.27 |
| P2 | -0.48 | 0.71 | 0.60 | 0.75 |
| P2 x P3 | 0.61 | 0.41 | 1.15 | 1.00 |
| P2 x P4 | 1.52 | 0.52 | 0.65 | 0.90 |
| P2 x P5 | -0.50 | 1.19 | 1.49 | 0.96 |
| P3 | 1.01 | 0.92 | 1.08 | 0.69 |
| P3 x P4 | 1.62 | 0.78 | 1.25 | 1.00 |
| P3 x P5 | 0.87 | 0.84 | 0.84 | 1.02 |
| P4 | 0.99 | 0.00 | 0.81 | 1.20 |
| P4 x P5 | 0.96 | 1.46 | 1.24 | 0.98 |
| P5 | 0.50 | 1.41 | 0.73 | 0.98 |

## Combining ability estimates

Estimates of the general combining ability effects (gi) of each parental genotype for all studied traits are presented in Table (5). Inbred lines P1, P2 and P5 exhibited negative and highly significant (gi) effects for plant and ear height, respectively under the normal environment. While P1, P4 and P5, respectively for plant height and P1 and P2 for ear height showed negative and highly significant (gi) effects under drought conditions, indicating that, those inbred lines posses favorable genes for developing improved hybrids with short plants. However, the inbred lines P1 and P4 under normal conditions and P3 under drought conditions exhibited positive and highly significant (gi) effects for grain yield per plant. The inbred line P1 showed positive and highly significant (gi) effects for ear diameter under normal and drought conditions. The inbred line P3 under normal conditions and P2 and P3 under drought conditions exhibited positive and highly significant (gi) effects for number of rows per ear .The inbred lines P2 and P3 under drought conditions and P2 under normal conditions showed positive and highly significant (gi) effects for number of kernels per row. The inbred lines P1 and P4 under normal conditions and P4 under drought conditions exhibited positive and highly significant (gi) effects for 100 kernels weight. This is of practical interest in breeding programs for developing high grain yield per plant and one or more of the remaining traits under normal and drought conditions.

**Table 5. Estimates of general combining ability effects for the parental genotypes evaluated under normal and stress environments (env.) as well as for their combined (comb.) data..**

| Parental Genotype | Env. | Plant height cm | Ear height cm | Ear length cm | Ear diameter cm | No. of rows / ear | No. of kernels/ row | 100 kernels weight g | Grain yield/ plant g |
|---|---|---|---|---|---|---|---|---|---|
| P1 | Normal | -10.29** | -6.26** | 0.09 | 0.17** | 0.26 | 0.66 | 0.93* | 8.18** |
| | Drought | -12.16** | -4.06** | -0.45* | 0.16** | -0.59** | -1.25* | 0.53 | -2.28 |
| | Combined | -11.22 | -5.16 | -0.18 | 0.16 | -0.17 | -0.30 | 0.73 | 2.95 |
| P2 | Normal | -7.43** | -4.69** | 0.21 | -0.10 | -0.17 | 1.37* | -1.83** | -6.01** |
| | Drought | 9.51** | -5.25** | 0.36 | -0.06 | 0.60** | 1.94** | -0.61 | 2.87 |
| | Combined | 1.04 | -4.97 | 0.29 | -0.08 | 0.21 | 1.66 | -1.22 | -1.57 |
| P3 | Normal | 19.48** | 12.51** | -0.13 | 0.02 | 0.97 | 0.56 | -0.78 | -4.2* |
| | Drought | 10.98** | 6.56** | 0.15 | 0.09 | 0.79** | 1.80** | -0.66 | 3.34* |
| | Combined | 15.23 | 9.53 | 0.01 | 0.05 | 0.88 | 1.18 | -0.72 | -0.43 |
| P4 | Normal | 1.62 | 3.65** | -0.14 | -0.01 | -0.36 | -0.15 | 0.98* | 9.32** |
| | Drought | -2.64* | 2.04 | 0.38 | -0.13* | -0.59** | 0.09 | 0.77* | 1.91 |
| | Combined | -0.51 | 2.84 | 0.12 | -0.07 | -0.48 | -0.03 | 0.88 | 5.62 |
| P5 | Normal | -3.38* | -5.21** | -0.03 | -0.08 | -0.70** | -2.44** | 0.70 | -7.30** |
| | Drought | -5.69** | 0.71 | -0.45* | -0.05 | -0.21 | -2.58** | -0.04 | -5.85** |
| | Combined | -4.53 | -2.25 | -0.24 | -0.07 | -0.45 | -2.51 | 0.33 | -6.57 |
| LSD | (gi-gj) | | | | | | | | |
| 0.05 | Normal | 4.51 | 4.79 | 0.67 | 0.18 | 0.80 | 2.28 | 1.38 | 5.90 |
| | Drought | 4.20 | 4.17 | 0.66 | 0.20 | 0.65 | 1.81 | 1.28 | 4.95 |
| | Combined | 3.01 | 3.10 | 0.46 | 0.13 | 0.50 | 1.42 | 0.92 | 3.76 |
| 0.01 | Normal | 6.07 | 6.45 | 0.90 | 0.25 | 1.08 | 3.06 | 1.86 | 7.95 |
| | Drought | 5.65 | 5.61 | 0.88 | 0.27 | 0.88 | 2.44 | 1.73 | 6.67 |
| | Combined | 4.00 | 4.12 | 0.63 | 0.17 | 0.67 | 1.89 | 1.22 | 5.00 |

***,** indicate significant at 0.05 and 0.01 probability levels, respectively.**

Specific combining ability effects of the ten crosses for all studied traits under normal and drought conditions are presented in Table (6). Seven out of ten crosses under drought conditions and one hybrid (P1 x P4) under normal conditions for plant height and six crosses under drought conditions and two hybrids under normal conditions for ear height exhibited negative and significant specific combining ability effects, indicating that these crosses posses favorable genes for producing improved hybrids with short plant and low ear placement. For grain yield per plant, six out of ten crosses under normal conditions and three crosses under drought conditions showed positive and significant SCA effects. Regarding to ear length and ear diameter two out of ten crosses under normal and drought conditions, respectively exhibited positive and significant SCA effects. For number of kernels per row two out of ten hybrids under drought and one hybrid (P1 x P4) under normal conditions exhibited positive and significant SCA effects. For 100- kernels weight five out of ten crosses under normal and three crosses under drought conditions exhibited positive and significant SCA effects.

When a cross ranks highest for SCA effect such as the cross (1 x 4) for grain yield per plant and three or more of its attributes and at the same time ranks the best for its mean performance in the same trait, such cross would be considered as a good breeding material to improve this specific trait. Similar results were reported by Desai and Singh (2001), Abd El-Aty and Katta, (2002), El-Morshidy *et al* (2003) and El-Shouny *et al* (2003).

## SDS-Protein electrophoresis

Electrophoretic assays have been widely used as a rapid and accurate test to identify and characterize different crop cultivars. By the use of appropriate and refined techniques, it is now possible to actually fingerprint each cultivar to assess its identity and its agronomic properties. SDS-PAGE analysis of water soluble proteins was successfully used for the identification and prediction of heterosis and combining ability in maize and different field crops (Abd El-Tawab *et al* 1989 and Esmail *et al* 1999).

The electrophoretic patterns (SDS-PAGE) for water soluble proteins (albumin and globulin) of the five maize inbred lines and their ten hybrids are illustrated in Figure (1) and Table (7). From the SDS-PAGE analysis, 43 bands were detected with different molecular weights (MW) and relative mobilities (Rm). Numbers inside the table represent the intensity percentages (%) of each band out of the total column.

**Table 6. Estimates of specific combining ability effects for ten yellow maize crosses evaluated under normal and drought environments as well as for their combined data.**

| Genotypes | Env. | Plant height cm | Ear height cm | Ear length cm | Ear diameter cm | No. of rows/ ear | No. of kernels/ row | 100 kernel weight g | Grain yield/ plant g |
|---|---|---|---|---|---|---|---|---|---|
| P1 x P2 | Normal | 13.49** | 8.48* | -1.61** | -0.23 | 0.83 | 0.13 | -0.35 | -3.46 |
| | Drought | -16.25** | 1.57 | -0.38 | -0.31* | 0.08 | -2.10 | 2.81** | 4.03 |
| | Combined | -1.38 | 5.02* | -1.00** | -0.27** | 0.45 | -0.98 | 1.23 | 0.29 |
| P1 x P3 | Normal | 29.92** | 12.95** | 1.06* | -0.25 | 0.35 | 2.27 | 3.27** | -9.60* |
| | Drought | -31.00** | -10.24** | 1.33** | 0.07 | 0.88 | 5.05** | 5.19** | 2.22 |
| | Combined | -0.57 | 1.36 | 1.20** | -0.09 | 0.62 | 3.66** | 4.23** | -3.70 |
| P1 x P4 | Normal | -10.56** | -1.52 | 1.74** | 0.38** | 0.02 | 6.32** | 6.18** | 38.55** |
| | Drought | -15.78** | -3.71 | -1.24* | 0.73** | 0.94 | -2.24 | 3.76** | 23.32** |
| | Combined | -13.17** | -2.62 | 0.25 | 0.56** | 0.48 | 2.04 | 4.97** | 30.93** |
| P1 x P5 | Normal | 11.11** | 10.00** | 0.13 | 0.24 | 0.68 | -3.06 | 5.13** | -1.51 |
| | Drought | -4.40 | 1.62 | 0.43 | 0.75** | 0.22 | 2.43 | 1.57 | -11.25** |
| | Combined | 3.36 | 5.81* | 0.28 | 0.50** | 0.45 | -0.32 | 3.35** | -6.38* |
| P2 x P3 | Normal | 12.06** | 11.38** | 0.61 | 0.22 | 0.44 | -2.11 | 4.03** | 24.59** |
| | Drought | -36.06** | -11.71** | -1.15* | 0.02 | 0.37 | -0.48 | 1.33 | 1.75 |
| | Combined | -12.00** | -0.17 | -0.27 | 0.12 | 0.41 | -1.30 | 2.68** | 13.17** |
| P2 x P4 | Normal | 51.59** | 17.91** | 0.46 | -0.25 | 0.78 | 2.27 | -0.40 | 2.06 |
| | Drought | -12.44** | -3.86 | 0.29 | -0.19 | -0.59 | 3.91** | 1.24 | 5.51 |
| | Combined | 19.57** | 7.02** | 0.37 | -0.22* | 0.10 | 3.09** | 0.42 | 3.79 |
| P2 x P5 | Normal | 28.25** | 18.43** | 0.01 | -0.02 | -0.56 | 1.56 | 3.22** | 22.02** |
| | Drought | 0.60 | 8.48** | 0.28 | -0.16 | 0.37 | -0.10 | -1.29 | 10.94** |
| | Combined | 14.43** | 13.45** | 0.15 | -0.09 | -0.10 | 0.73 | 0..97 | 16.48** |
| P3 x P4 | Normal | 4.68 | 4.05 | -1.20* | 0.37** | 0.64 | 3.08 | 0.89 | 11.92** |
| | Drought | -18..92** | -8.33** | 0.67 | 0.16 | -0.11 | 2..38 | -1.05 | 4.03 |
| | Combined | -7.12** | -2.14 | -0.94** | 0.26** | 0.26 | 2.73* | -0.08 | 7..98** |
| P3 x P5 | Normal | 3.02 | -0.10 | 0..96 | 0.23 | -0.03 | 2.70 | -0.83 | 20.87** |
| | Drought | -12.21** | -4.67 | 0.69 | 0.08 | -0.16 | 2.38 | 1.10 | 6.13 |
| | Combined | -4.60 | -2.38 | 0.83* | 0.16 | -0.10 | 2.54* | 0.14 | 13.50** |
| P4 x P5 | Normal | 12.54** | 5.76 | 0.71 | 0.03 | -0.03 | 3.41 | 1.08 | 24.02** |
| | Drought | 41.08** | 19.52** | 1.76** | 0.41 | -0.11 | 0.43 | -0.33 | 20.22** |
| | Combined | 26.81** | 12.64** | 1.23** | 0.22* | -0.07 | 1.92 | 0.37 | 22.12** |
| LSD (Sij – Sik) | | | | | | | | | |
| 0.05 | Normal | 11.05 | 11.73 | 1.63 | 0.45 | 1.96 | 5.57 | 3.39 | 14.44 |
| | Drought | 10.27 | 10.21 | 1.61 | 0.48 | 1.60 | 4.44 | 3.14 | 12.13 |
| | Combined | 7.36 | 7.59 | 1.12 | 0.32 | 1.23 | 3.48 | 2.25 | 9.20 |
| 0.01 | Normal | 14.87 | 15.79 | 2.19 | 0.60 | 2.64 | 7.50 | 4.56 | 19.44 |
| | Drought | 13.83 | 13.75 | 2.16 | 0.65 | 2.15 | 5.98 | 4.23 | 16.33 |
| | Combined | 9.79 | 10.09 | 1.48 | 0.43 | 1.64 | 4.62 | 3.00 | 12.23 |
| LSD (Sij – Skl) | | | | | | | | | |
| 0.05 | Normal | 10.08 | 10.70 | 1.49 | 0.41 | 1.79 | 5.08 | 3.09 | 13.18 |
| | Drought | 9.39 | 9.33 | 1.47 | 0.44 | 1.46 | 4.05 | 2.87 | 11.07 |
| | Combined | 6.72 | 6.93 | 1.02 | 0.29 | 1.13 | 3.17 | 2.06 | 8.40 |
| 0.01 | Normal | 13.58 | 14.41 | 2.00 | 0.55 | 2.41 | 6.85 | 4.17 | 17.74 |
| | Drought | 12.64 | 12.56 | 1.97 | 0.59 | 1.97 | 5.46 | 3.86 | 14.90 |
| | Combined | 8.94 | 9.21 | 1.36 | 0.39 | 1.50 | 4.22 | 2.74 | 11.17 |

*,** indicate significant at 0.05 and 0.01 probability levels, respectively.

**Table 7. Densitometer analysis of water soluble proteins (SDS-PAGE) showing number of bands (B.no.), Relative mobility (Rm), molecular weight (Mw) and intensity as a percentage of total concentration for 5 x 5 maize diallel crosses.**

| B. No. | R.m | M.W. K.Da | Inbred Parents | | | | | Hybrids | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 | 1x2 | 1x3 | 1x4 | 1x5 | 2x3 | 2x4 | 2x5 | 3x4 | 3x5 | 4x5 |
| 1 | 0.011 | 224.77 | | | | 4.22 | 2.78 | | | | | 3.89 | 4.29 | | | 3.82 | |
| 2 | 0.022 | 211.02 | | 4.65 | 4.61 | | | | | 4.01 | | | | | | 1.88 | 2.25 |
| 3 | 0.051 | 167.41 | | | 2.75 | 2.78 | 1.58 | | | | 1.78 | 3.98 | 2.86 | | 2.92 | | |
| 4 | 0.056 | 162.67 | | 2.78 | | | | 2.94 | 2.53 | | | | | 2.93 | 1.93 | 1.46 | |
| 5 | 0.061 | 158.86 | | | | | | | | 2.27 | | | | 3.04 | | | |
| 6 | 0.070 | 151.95 | 3.05 | 5.53 | 3.90 | 4.31 | 5.15 | 3.48 | 4.00 | 4.43 | 3.65 | 2.78 | 5.27 | | 3.23 | 2.83 | 1.50 |
| 7 | 0.101 | 135.52 | 2.84 | 2.3 | 2.57 | 3.12 | 2.59 | 2.58 | 1.74 | 1.86 | 1.95 | 2.75 | 1.85 | | 2.58 | | |
| 8 | 0.124 | 122.76 | 3.25 | 3.76 | 4.00 | 3.30 | 2.79 | 2.36 | 2.62 | 3.28 | 2.92 | 1.97 | 2.54 | 2.62 | 3.72 | 2.53 | 2.02 |
| 9 | 0.152 | 111.44 | | 1.80 | 3.76 | | | | | | | | 2.57 | | | 2.36 | 2.13 |
| 10 | 0.158 | 111.42 | 2.90 | | | 2.68 | 3.79 | | 2.59 | | 2.55 | | | | | | |
| 11 | 0.164 | 106.92 | | 3.58 | | | | 2.81 | | 1.99 | 1.88 | 3.48 | 3.06 | | 3.20 | 1.43 | |
| 12 | 0.177 | 100.81 | | | | 1.58 | | | | | 1.40 | | | | | | |
| 13 | 0.187 | 91.47 | 3.10 | | | | | | | | | | | | | | 2.70 |
| 14 | 0.191 | 94.05 | | | 2.28 | | | | | | | | | 2.39 | 1.85 | | |
| 15 | 0.205 | 88.58 | | | | 2.79 | 3.14 | 2.04 | | 2.98 | 1.19 | 2.78 | 2.54 | | | | |
| 16 | 0.243 | 81.96 | 10.7 | 12.5 | 11.7 | 12.2 | 8.86 | 12.8 | 13.8 | 14.5 | 10.3 | 10.1 | 13.4 | 7.99 | 8.65 | 7.30 | 4.04 |
| 17 | 0.276 | 73.34 | | 2.70 | 1.72 | 1.01 | | 1.97 | | | 2.91 | | | 1.43 | 1.61 | 1.89 | 0.92 |
| 18 | 0.282 | 72.45 | 1.80 | | | | 1.36 | | 1.87 | 1.38 | | 1.79 | 1.25 | | | 1.36 | 1.45 |
| 19 | 0.296 | 67.22 | | 2.44 | 1.38 | | 1.63 | 1.78 | | | 1.53 | | 1.65 | | 1.77 | | |
| 20 | 0.306 | 66.02 | | | | 1.87 | | | 1.31 | 1.17 | | 2.07 | | | 1.23 | | |
| 21 | 0.312 | 65.16 | 1.52 | | | 1.04 | 1.25 | 0.76 | | 0.95 | | | | | | | |
| 22 | 0.323 | 62.68 | | 1.09 | | | | | | | | 1.20 | | 0.97 | 1.22 | | 1.67 |
| 23 | 0.333 | 61.65 | | 1.35 | | | 1.14 | 1.06 | | 1.19 | | | 1.13 | | | | |
| 24 | 0.348 | 59.67 | | | 1.25 | | | 0.74 | 0.81 | 0.92 | | | | 0.51 | 1.13 | | |
| 25 | 0.435 | 47.53 | 2.47 | | | | | | | | 1.63 | 1.66 | 1.59 | | | | 4.72 |
| 26 | 0.450 | 46.03 | | 2.58 | 3.01 | | | | | 3.14 | 2.48 | 4.05 | 1.95 | 3.46 | 6.56 | 5.87 | |
| 27 | 0.457 | 44.68 | 1.05 | | | | | | | | | | | | | | 1.05 |
| 28 | 0.466 | 44.17 | | | | 4.48 | 7.08 | 6.66 | 4.16 | | 1.33 | | 0.80 | 1.22 | 2.13 | 0.72 | |
| 29 | 0.476 | 43.24 | | 1.66 | 1.12 | | | | | 1.07 | | 0.91 | | | | | |
| 30 | 0.488 | 42.36 | | | | 1.28 | 2.32 | 1.83 | 0.91 | | | 0.55 | | | | 0.77 | |
| 31 | 0.525 | 40.05 | | 0.45 | 0.62 | 0.52 | | | 0.65 | 1.16 | | 0.70 | 0.56 | 1.08 | 1.34 | | 1.42 |
| 32 | 0.544 | 38.93 | 0.99 | | | | 0.73 | 0.55 | | 0.70 | | | | | | | 1.36 |
| 33 | 0.563 | 37.84 | | 0.63 | 0.53 | 0.49 | | | 0.75 | 1.00 | | | 0.60 | | 1.21 | | |
| 34 | 0.575 | 30.85 | | | | | 0.99 | 0.59 | | | | 2.40 | | | 0.69 | | 1.17 |
| 35 | 0.636 | 34.54 | | | | | 0.78 | 0.65 | | | | | | | | | |
| 36 | 0.695 | 32.07 | | | | | 0.87 | 1.04 | | | | | | | 0.74 | | 1.26 |
| 37 | 0.702 | 31.68 | | | | | | | | | | | | | | | 0.94 |
| 38 | 0.720 | 31.13 | | | | | | | | 0.65 | | 0.79 | 0.49 | 0.80 | 0.76 | | 2.10 |
| 39 | 0.744 | 29.93 | | | | | 2.93 | 0.80 | | 0.88 | | 0.79 | | | | | |
| 40 | 0.753 | 29.68 | 1.47 | | | | 0.59 | 1.09 | | | | | | 1.35 | 1.26 | 1.51 | 2.70 |
| 41 | 0.774 | 28.27 | | | | | | | | 1.81 | 1.61 | 1.74 | 1.09 | | | | |
| 42 | 0.783 | 28.29 | | 1.91 | 2.20 | 0.99 | | | 1.26 | | | | | | | | |
| 43 | 0.792 | 27.57 | | | | | 1.34 | 1.54 | | | | | | | | | |

**Numbers inside the table represent proper intensity percentages of each band**

**SDS-SP 1→15**

**Figure 1.SDS Electrophoretic patterns of water soluble protein in 15 genotypes of yellow maize**

Two bands are commonly present in all five parents and their ten hybrids of MW 122.76 and 81.96 KDa. These bands were considered as marker bands for these genotypes. The five inbred lines were discriminated from each other by some unique bands, where inbred line P1 showed three bands of MW 91.47, 47.53 and 44.68 KDa. . The inbred line P2 characterized by three bands of MW 162.67, 106.92 and 62.68 KDa.. The inbred line P3 showed two bands of MW 94.05 and 59.67 KDa.. Two bands of MW 100.81 and 66.02 KDa. characterized the inbred line P4. Five bands of MW 30.85, 34.54, 32.07 29.93 and 27.57 KDa. characterized the inbred line P5 .From these results it is concluded that the analysis of soluble protein electrophoretic bands could be a useful tool for the identification and characterization of the five inbred lines of yellow maize. Variations among different field crops in SDS-protein banding patterns have been reported by many authors (Abd El-Tawab *et al* 1978 , 1989, Afiah *et al* 1999 and Esmail *et al* 1999). Regarding the hybrids, six out of ten crosses (P1 x P2, P1 x P4, P2 x P3, P2 x P4, P3 x P4 and P4 x P5) exhibited number of bands which exceeded their respective parents (Table7) and were distinguished by having more hybrid bands. In the same time, most of these hybrids showed substantial hybrid vigor with regard to grain yield per plant under drought conditions (Table3) and positive significant specific combining ability effects under drought conditions (Table 6) . Four hybrids (P1 x P3, P1 x P5, P2 x P5 and P3 x P5) exhibited a number of bands which did not exceed the number of bands of their parents. These crosses showed insignificant and negative heterosis and specific combining ability under drought conditions (Tables 3 and 6), except the hybrid P2 x P5 which had positive and significant heterosis and specific combining ability.

These results indicated to some extent the effectiveness of using soluble seed protein electrophoresis in the identification of the highly heterotic hybrids and high specific combining ability under drought conditions as biochemical genetic markers associated with hybrid vigor and specific combining ability in yellow maize hybrids.

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# تحليل الهجن التبادلية لبعض الصفات الكمية فى الذرة الصفراء تحت الظروف المثلى وظروف الإجهاد المائى

## ١ . الادله الوراثية البيوكيماوية لقوة الهجين والقدرة على التالف

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يهدف البحث إلى دراسة قوة الهجين والقدرة على الائتلاف فى الذرة الصفراء تحت الظروف المثلى وظروف الإجهاد المائى ( منع الرى بعد الريه الثانيه ولمدة ثلاث ريات متتاليه ) بمحطة البحوث والتجارب الزراعية بالمركز القومى للبحوث_شلقان_قليوبية وكذلك التعرف على الأدلة الوراثية البيوكيماوية لتحمل الجفاف بإستخدام خمسة سلالات مرباة داخليا وكافة الهجن التبادلية دون العكسية (عشرة هجن)،حيث تم تقييمها فى موسم ٢٠٠٤ فى تصميم تجريبى قطاعات كاملة العشوائية من ثلاثة مكررات وتم أخذ القراءات على صفات إرتفاع النبات(سم)، إرتفاع الكوز (سم)،طول الكوز (سم)،قطر الكوز (سم)، عدد الحبوب بالصف، عدد الصفوف بالكوز، وزن ١٠٠ حبه (جرام)وإنتاجيه النبات من الحبوب (جرام). وتم تحليل النتائج بطريقة جريفنج ١٩٥٦ (الموديل الاول_ الطريقة الثانية)،ويمكن تلخيص أهم النتائج فيما يلى:-

١-كان متوسط مجموع المربعات الراجع إلى كل من التراكيب الوراثيه والآباء والهجن عالى المعنويه لكل الصفات المدروسه تحت كلا من الظروف المثلى وظروف الجفاف ما عدا طول الكوز وقطر الكوز وعدد الصفوف بالكوز ووزن ١٠٠ حبه للآباء وعدد الصفوف بالكوز وعدد الحبوب بالصف للهجن تحت الظروف المثلى .

٢- أظهر تباين البيئات فروقا معنوية كبيرة فى كل الصفات تحت الدراسة ،

٣- أظهرت النسبة بين تباين كلا من القدرة العامة والخاصة على التالف أن الجزء الأكبر من التباين الوراثى الكلى يرجع إلى التباين الغير مضيف وذلك لمعظم الصفات المدروسة تحت الظروف المثلى وظروف الإجهاد المائى .

٤- أوضح التفاعل بين كل من القدرة العامة والخاصة على التالف والبيئة أنه عالى المعنوية لمعظم الصفات تحت الدراسة ما عدا صفات طول الكوز وقطر الكوز وعدد الحبوب بالصف ووزن المائة حبة لتفاعل القدرة العامة على التالف والبيئة وصفة عدد الصفوف للكوز لتفاعل القدرة الخاصة على التالف والبيئة حيث كان غير معنوى مشيرا إلى تأثر كلا من الفعل الجينى المضيف والفعل الجينى الغير مضيف بالتغير فى ظروف البيئة .

٥-كانت أحسن التراكيب الوراثيه الأبوية بالنسبة للقدرة العامة على التالف فى صفة محصول النبات من الحبوب وإثنين أو اكثر من الصفات المساهمه فيه هى السلالتان P1 و P4 تحت الظروف المثلى والسلالة P3 تحت ظروف الجفاف .

٦- أظهرت ستة هجن تحت ظروف الرى العادى وثلاثة هجن تحت ظروف الجفاف قدرة خاصة على التالف عالية المعنوية وموجبة بالنسبة لصفة محصول النبات من الحبوب وإثنين أو أكثر من الصفات المساهمة وكان أحسن هذه الهجن هو الهجين P1xP4 تحت كلا من الظروف المثلى وظروف الجفاف .

٧- أظهر التفريد الكهربى للبروتينات الذائبة أنه أداة فعالة للتعرف على الخمس سلالات المرباة داخليا من الذرة الصفراء كما أظهر أيضاً كفاءة فى التعرف على قوة الهجين والقدرة الخاصة على الائتلاف تحت ظروف الجفاف فى هجن الذرة الصفراء٠

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