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# HETEROSIS AND COMBINING ABILITY IN MAIZE USING DIALLEL CROSSES AMONG SEVEN NEW INBRED LINES

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## ABSTRACT

A half diallel cross between 7 inbred lines of maize was evaluated under two different nitrogen rates for six quantitative characters. Nitrogen rates, genotypes, parents, hybrids and parents *vs* crosses mean squares were significant for all traits. Significant genotype x nitrogen rate mean squares were obtained for days to 50% maturity, No. of rows ear$^{-1}$ and shelling%. Significant interaction mean squares between hybrids x nitrogen rates were detected for days to 50% maturity, No. of rows ear$^{-1}$ and grain yield plant$^{-1}$. General and specific combing ability (GCA and SCA) mean squares were significant for all traits. GCA/SCA ratios revealed that the additive and additive x additive types of gene action were the most important expressions for days to 50% maturity, number of rows ear-1 and shelling% in both and nitrogen rates and combined analysis. Significant interaction mean squares between nitrogen rates and GCA and SCA were detected for most traits. The crosses $P_1xP_2$ and $P_1xP_7$ at the low nitrogen level, $P_1xP_4$, $P_1xP_6$, $P_1xP_7$ and $P_2xP_5$ hybrids at the normal nitrogen level and the hybrid $P_1xP_7$ in the across nitrogen levels, were out yielded the check hybrid (Pioneer 30K8). Also, single cross $P_1xP_7$ did not differ significantly from the hybrid Hytech 2031 in low nitrogen rate and combined analysis for grain yield plant$^{-1}$. The parental inbred line No. 4 gave a good combiner for No. of rows ear$^{-1}$ and grain yield plant$^{-1}$ at both and across nitrogen rate. The most desirable inter and intra allelic interactions were presented by combinations: $P_1xP_6$, $P_1xP_7$, $P_2xP_6$ and $P_5$ $xP_6$ for 100-kernel weight, $P_1xP_2$, $P_1xP_4$, $P_1xP_6$, $P_1xP_7$, $P_2xP_3$, $P_2xP_5$, $P_2xP_7$ and $P_4xP_7$ for grain yield plant$^{-1}$ and $P_1xP_4$ and $P_4xP_7$ for shelling%. These crosses may be prime importance in breeding programs either towards hybrid maize production or synthetic varieties composed of hybrids which involved the good combiners for the traits in view.

**Keywords:** General combining ability (GCA), Specific combining ability (SCA), Additive, Non- additive, Gene action, Nitrogen, Heterosis, Maize

## INTRODUCTION

Maize (*Zea mays* L.) is considered the third cereal crop after rice and wheat all over the world for production and consumption. In addition to its use as a human food, it is also utilized as a poultry and livestock feed and also as a fodder. Moreover, it is also used for industrial purposes such as glue, soap, paint, insecticides, toothpaste, shaving cream, rubber tires, rayon, molded plastics, fuels and others (White and Johnson, 2003).

Nowadays, corn breeders do their best to explore the genetic material in order to develop new maize genotypes which characterized by high yielding potentiality and better quality. To do that they need enough knowledge about the type and relative amount of genetic variance components and their interaction by environments as well as heterosis for yield and its component. One of the most informative methodology in this concern is diallel analysis system which is widely and extensively used for estimating the types of gene action. The two main genetic parameters of diallel analysis are GCA and SCA which are essential in developing breeding strategies. In this concern, several investigators reported that additive gene action was responsible for the inheritance of grain yield and most of its contributing characters. Among those are: Sedhom, 1994; Ahmed *et al*., 2000; Al-Naggar *et al*., 2002; Alamnie *et al*., 2006; El-Badawy, 2006 and Sedhom *et al*., 2007. However, Dadheech and Joshi, 2007, Barakat and Osman, 2008 and Irshad-El-Haq *et al*., 2010 reported that non additive gene action was more important in the inheritance grain yield and most other agronomic traits in maize. While Iqbal *et al*., 2007; Akbar *et al*., 2008 and Hefny 2010 they reported that both additive and non additive gene effects were important in the genetic expression of maize yield and its contributing traits.

Therefore, the main objectives of this investigation were: To establish the magnitude of heterosis as well as both general (GCA) and specific (SCA) combining abilities effects and their interaction with the nitrogen fertilization rates.

## MATERIALS AND METHODS

**Plant materials**

Seven yellow inbred lines of corn (*Zea mays* L.) were used as parents in this study. Moshtohor $P_1$ (M9), $P_2$ (M41), $P_3$ (M55), $P_4$ (M120), $P_5$ (M21), $P_6$ (M46) and $P_7$ (M39) were developed in the Department of Agronomy, Faculty of Agriculture, Moshtohor, Benha Univerity by Prof. Dr. A.A.M. El-Hosary.

**Field experiments**

In the first season (summer 2010) the seven inbred lines were sown in $18^{th}$ May, $28^{th}$ May and 8th June to avoid differences in flowering time and to secure enough hybrid seed. All possible combinations without reciprocals were made between the seven inbred lines by hand method giving a total of 21 crosses. In the second season (summer 2011), two adjacent experiments were conducted involved parents, 21 hybrids and Single Cross (S.C.) (Hytech 2031) and S.C. Pioneer 30K8 (Check varieties) were planted in May $16^{th}$ at the Agricultural Research and Experimental Station of the Fac. of Agric., Moshtohor. Two experiments each with different nitrogen levels were conducted to evaluate the parents, 21 hybrids and Single Cross (S.C.) Hytech 2031 and S.C. Pioneer 30K8 (Check varieties). The first experiment received 60 kg N $fed.^{-1}$ and the second one received 120 kg N $fed.^{-1}$. A randomized complete block design with three replications was used for each experiment. Each plot consisted of two ridges of five meters length and 70 cm width. Hills were spaced at 25 cm with three kernels per hill on one side of the ridge. The seedlings were thinned to one plant per hill. The rest of cultural practices were followed as usual for ordinary maize field in the area. Random of 20 guarded plants in each plot was taken to evaluate, days to 50% maturity (days) was recorded as the number of days from sowing to the day when all husks of ears turned brown, No. of kernels $row^{-1}$, No. of row $ear^{-1}$, 100-kernel weight (g), grain yield plant$^{-1}$ (g) was adjusted for 15.5% moisture and shelling%.

**Statistical analysis**

The obtained data were statistically analyzed for analysis of variance by using computer statistical program MSTAT-C. General and specific combining ability estimates were estimated according to (Griffing, 1956) diallel cross analysis designated as method 2 model I for each experiment. The combined analysis of the two experiments was carried out whenever homogeneity of variance was detected (Gomez and Gomez, 1984). Duncan's multiple range test (Duncan, 1955) was used to differentiate between means.

## RESULTS AND DISCUSSION

The analysis of variance for ordinary analysis of the two nitrogen rates as well as the combined for all traits under study is given in Table 1. Mean squares due to nitrogen rates were found to be significant for all studied traits except shelling%, with high magnitudes in high nitrogen rate compared to those in low one. The increase in mean performance in these traits at high rate of nitrogen might be due to the simulating effect of nitrogen on metabolic process in maize plant. These results are in agreement with those obtained by (Ayub *et al.*, 2002, Eltelib *et al.*, 2006; Hefny and Aly, 2008; Ngaboyisonga *et al.*, 2009; Tamilarasi and Vetriventhan, 2009 and EL-Badawy *et al.*, 2010).

Genotypes, parental inbred lines, crosses and parent *vs* crosses mean squares were significant for all studied traits for each nitrogen rate as well as for the combined analysis across nitrogen rates except for parent's *vs* crosses mean square due to days to 50% to maturity at low nitrogen rate. This indicates the wide diversity between the genetic materials used in the present study.

Significant genotype x nitrogen rate mean squares were obtained for days to 50% maturity, No. of rows ear$^{-1}$ and shelling% (Table 1), revealing that the performance of genotypes differed from nitrogen rate to another. However, insignificant interaction mean squares between parents x nitrogen and hybrids x nitrogen rates were detected for all traits except for hybrid x nitrogen level for days to 50% maturity, No. of rows ear$^{-1}$ and grain yield plant$^{-1}$, revealing that the performances of parents and crosses were responded similar to environmental changes. For the exceptional traits, significant interaction mean squares between hybrid and nitrogen rates were detected indicating that, these hybrids behaved some what differently from nitrogen rate to another. Also, insignificant interaction between mean squares due to parent *vs* crosses and nitrogen rate were obtained for all traits except days to 50% maturity and shelling%. This result indicates that the heterotic effects were not affected by the nitrogen changes.

**Mean performances**

The mean performances of the tested seven parental inbred lines and their 21 hybrids and two check varieties at each nitrogen rate and as an average over the nitrogen rates are present in Table 2.

**Table 1: Mean squares from ordinary analysis of variance and combining ability for each Nitrogen level as well as the combined across them for all traits under study.**

| S.O.V. | d.f. | | Trait | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | days to maturity | | | no of rows ear⁻¹ | | | no of kernels row⁻¹ | | |
| | S. | Comb | N1 | N2 | Comb | N1 | N2 | Comb | N1 | N2 | Comb |
| Nitrogen rate | | 1 | | | 182.35** | | | 4.95** | | | 241.47** |
| Rep/N | 2 | 4 | 2.541* | 0.29 | 1.41 | 5.01** | 0.11 | 2.56* | 1.34 | 2.22 | 1.78 |
| Genotypes | 27 | 27 | 16.87** | 32.35** | 45.35** | 7.55** | 4.23** | 9.99** | 61.52** | 71.10** | 124.29** |
| parent | 6 | 6 | 44.23** | 63.09** | 106.07** | 2.26* | 1.78** | 2.50* | 34.63** | 32.63** | 63.89** |
| Cross | 20 | 20 | 9.50** | 23.06** | 28.47** | 7.73** | 3.72** | 9.52** | 35.27** | 45.84** | 70.90** |
| Par.vs.cr. | 1 | 1 | 0.09 | 33.66** | 18.60** | 35.58** | 29.04** | 64.46** | 747.87** | 807.07** | 1554.38** |
| G/N | | 27 | | | 3.87* | | | 1.78* | | | 8.34 |
| par./N | | 6 | | | 1.26 | | | 1.54 | | | 3.37 |
| Cr./N | | 20 | | | 4.09* | | | 1.94* | | | 10.21 |
| Par.vs.cr.Vs.N | | 1 | | | 15.14** | | | 0.17 | | | 0.56 |
| Error | 54 | 108 | 0.56 | 0.72 | 0.64 | 0.60 | 0.31 | 0.46 | 4.99 | 3.43 | 4.21 |
| GCA | 6 | 6 | 15.82** | 41.63** | 54.18** | 4.12** | 2.72** | 6.55** | 8.57** | 6.70** | 11.87** |
| SCA | 21 | 21 | 2.71** | 1.97** | 3.95** | 2.05** | 1.03** | 2.41** | 23.91** | 28.55** | 49.93** |
| GCA x N | | 27 | | | 3.87** | | | 1.78** | | | 8.33** |
| SCA x N | | 6 | | | 3.26** | | | 0.29 | | | 3.60 |
| Error | 54 | 21 | 0.19 | 0.24 | 0.73 | 0.20 | 0.10 | 0.68 | 1.66 | 1.14 | 2.54 |
| GCA/SCA | | 108 | 5.84 | 21.11 | 13.70 | 2.00 | 2.63 | 2.72 | 0.36 | 0.23 | 0.23 |
| GCA x N/GCA | | | | | 0.07 | | | - | | | - |
| SCA x N/SCA | | | | | 0.82 | | | - | | | - |

Table 1: Cont.

| S.O.V. | d.f. | | Trait | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 100-kernel weight | | | grain yield plant⁻¹ | | | shelling% | | |
| | S. | Comb | N1 | N2 | Comb | N1 | N2 | Comb | N1 | N2 | Comb |
| Nitrogen rate | | 1 | | | 319** | | | 21536.75** | | | 1.49 |
| Rep/N | 2 | 4 | 5.17 | 7.65 | 6.41 | 832.04** | 23.00 | 427.52 | 0.30 | 1.18 | 0.74 |
| Genotypes | 27 | 27 | 104.80** | 95.76** | 193.05** | 5856.12** | 6132.681** | 11570.16** | 68.92** | 51.07** | 110.93** |
| parent | 6 | 6 | 15.11* | 24** | 37.33** | 971.17** | 2280.35** | 2960.09** | 127.22** | 87.21** | 207.10** |
| Cross | 20 | 20 | 19.46* | 26.8** | 37.23** | 1878.57** | 2252.97** | 3657.31** | 27.15** | 34.39** | 54.33** |
| Par.vs.cr. | 1 | 1 | 2349.72** | 1905.75** | 4243.86** | 114716.80** | 106840.89** | 221487.68** | 554.40** | 187.74** | 666.01** |
| G/N | | 27 | | | 7.52 | | | 418.64 | | | 9.05* |
| par./N | | 6 | | | 1.78 | | | 291.43 | | | 7.33 |
| Cr./N | | 20 | | | 9.03 | | | 474.234* | | | 7.21 |
| Par.vs.cr.Vs.N | | 1 | | | 11.61 | | | 70.02 | | | 56.12** |
| Error | 54 | 108 | 5.31 | 4.91 | 5.11 | 136.97 | 105.25 | 121.11 | 1.97 | 2.48 | 2.23 |
| GCA | 6 | 6 | 5.10** | 8.70** | 12.49** | 598.83** | 571.04** | 1134.32** | 27.23** | 27.06** | 48.78** |
| SCA | 21 | 21 | 43.457** | 38.557** | 79.16** | 2338.67** | 2465.13** | 4634.54** | 21.76** | 14.15** | 33.60** |
| GCA x N | | 27 | | | 7.51** | | | 418.64* | | | 9.047** |
| SCA x N | | 6 | | | 1.32 | | | 35.55 | | | 5.51* |
| Error | 54 | 21 | 1.77 | 1.64 | 2.85 | 45.66 | 35.08 | 169.26 | 0.66 | 0.83 | 2.30 |
| GCA/SCA | | 108 | 0.12 | 0.23 | 0.16 | 0.26 | 0.23 | 0.24 | 1.25 | 1.91 | 1.45 |
| GCA x N/GCA | | | | | - | | | - | | | 0.19 |
| SCA x N/SCA | | | | | - | | | - | | | 0.16 |

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

S. refers to single nitrogen level. N1, N2 and Comb. refer to first, second nitrogen level and combined analysis, respectively.

**Table 2 : Meanperformance of all genotype under study at the two nitrogen levels as well as the combind across them.**

| Cross | Trait | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | days to maturity | | | no of rows ear$^{-1}$ | | | no of kernels row$^{-1}$ | | |
| | N1 | N2 | comb. | N1 | N2 | comb. | N1 | N2 | comb. |
| 1x1 | 103.8 AB | 107.0 BD | 105.4 BC | 13.40 DF | 12.00 HI | 12.70 DF | 25.60 M | 29.13 LM | 27.37 P |
| 2x2 | 97.57 LM | 101.0 LN | 99.28 IL | 10.83JK | 10.87 J | 10.85 H | 27.53 M | 27.93 M | 27.73 P |
| 3x3 | 102.50 CD | 106.3 CE | 104.4 CD | 10.93 IK | 12.60 DI | 11.77 FG | 28.63 LM | 32.40 KL | 30.52 O |
| 4x4 | 97.00 M | 99.67 NP | 98.33 L | 11.93 FJ | 13.33 CF | 12.63 DF | 34.47 FK | 35.88 HJ | 35.17 JL |
| 5x5 | 94.87 N | 96.33 S | 95.60 M | 11.33 HK | 11.80 I | 11.57 GH | 31.67 KL | 31.90 KL | 31.78 NO |
| 6x6 | 102.4 CD | 105.3 EG | 103.8 DE | 12.07 FJ | 12.27 FI | 12.17 EG | 32.93 IK | 36.27 GJ | 34.60 KM |
| 7x7 | 104.7 A | 109.0 A | 106.8 A | 11.77 GK | 12.57DI | 12.17 EG | 26.60 M | 29.30 LM | 27.95 P |
| 1x2 | 98.93 IL | 101.0 LN | 99.97IK | 12.25 FJ | 13.32 CF | 12.78 DE | 37.88 CG | 43.33 BC | 40.60 CF |
| 1x3 | 101.8 CE | 105.6 DF | 103.7 DF | 13.00 EG | 13.55 CD | 13.28 CD | 38.13 CG | 38.30 FH | 38.21 FI |
| 1x4 | 99.40 HK | 101.3 KM | 100.4 HJ | 14.80 BC | 14.00 C | 14.40 B | 39.50 BE | 39.90 CF | 39.70 DG |
| 1x5 | 98.00 KM | 99.33 OQ | 98.67 KL | 12.80 EH | 12.40 EI | 12.60 DF | 32.40 JL | 34.70 IK | 33.55 KN |
| 1x6 | 102.4 CD | 105.8 DF | 104.1 CD | 12.60 FH | 12.75 DI | 12.68 DF | 37.50CH | 37.60 FI | 37.55 GJ |
| 1x7 | 104.3 A | 107.7 AC | 106.0 AB | 12.20 FJ | 13.17 CG | 12.68 DF | 43.03 B | 43.21 BC | 43.12 BC |
| 2x3 | 98.00 KM | 100.0 MO | 99.00 JL | 14.50 BD | 13.60 CD | 14.05 BC | 35.20 FK | 41.90 CE | 38.55 FI |
| 2x4 | 98.62 JL | 99.00 OR | 98.81 KL | 14.20 CE | 16.50 A | 15.35 A | 39.73 BE | 42.90 CD | 41.32 BE |
| 2x5 | 99.80 GJ | 98.00 QR | 98.90KL | 12.73 FH | 12.73 DI | 12.73 DE | 41.47 BC | 42.80CD | 42.13 BD |
| 2x6 | 102.2 CD | 102.7 IK | 102.5 EG | 12.40 FI | 13.35 CF | 12.88 DE | 34.10 GK | 38.33 FH | 36.21 HK |
| 2x7 | 101.9 CE | 102.8 HK | 102.4 FG | 12.60 FH | 12.60 DI | 12.60 DF | 41.10 BD | 46.30 B | 43.70 B |
| 3x4 | 98.80 IL | 101.0 LN | 99.90 IK | 15.80 AB | 15.50 B | 15.65 A | 32.50 JL | 32.28KL | 32.39 MO |
| 3x5 | 99.20 IK | 98.33 PR | 98.77 KL | 11.73 GK | 13.50 CE | 12.62 DF | 36.63 EJ | 42.00 CE | 39.32 EG |
| 3x6 | 100.7 EH | 104.3 FH | 102.5 EG | 12.80 EH | 13.30 CF | 13.05 DE | 32.70 JL | 35.75 HJ | 34.23 KN |
| 3x7 | 100.2 FI | 103.3 HJ | 101.8 GH | 12.85 EH | 12.20 GI | 12.53 DF | 33.30 HK | 38.70EH | 36.00 IK |
| 4x5 | 98.20 KM | 97.67 RS | 97.93 L | 15.60 AC | 15.10 B | 15.35 A | 37.10 DI | 38.93EH | 38.01FI |
| 4x6 | 101.5 DF | 103.0 HJ | 102.2 G | 16.40 A | 15.10 B | 15.75 A | 34.00 GK | 31.30KL | 32.65LO |
| 4x7 | 102.9 BC | 105.0 EG | 103.9 D | 15.40 AC | 13.60 CD | 14.50 B | 38.70 CF | 39.00EH | 38.85EH |
| 5x6 | 100.0 GJ | 101.0 LN | 100.5 HI | 11.50 GK | 13.20 CG | 12.35 DG | 32.00 KL | 33.45JK | 32.73 LO |
| 5x7 | 100.8 EG | 102.3 JL | 101.6 GH | 11.80 GK | 12.75 DI | 12.28 EG | 38.25 CG | 39.6DG | 38.93 EG |
| 6x7 | 99.17 IK | 104.0 GI | 101.6 GH | 10.40 K | 12.60 DI | 11.50 GH | 31.80 KL | 38.50 EH | 35.15 JL |
| Pioneer 30K8 | 102.0 CD | 104 FH | 103EG | 11.6GK | 12.50 DI | 12.05 EG | 35.00 FK | 38.10 FH | 36.5 HK |
| Hytech 2031 | 105.0 A | 108.0 AB | 106.5 AB | 12.00 FJ | 13.00 CH | 12.50 DF | 47.60 A | 53.10 A | 50.35 A |
| Over mean | 100.56 | 102.66 | 101.61 | 12.74 | 13.11 | 12.93 | 35.14 | 37.59 | 36.36 |

N1, N2 and Comb. refer to first, second nitrogen level and combined analysis, respectively.
The capital letters indicate significant difference between means (Duncan test (LSR value, $P<0.05$).
The alphabets descending from A to Z refer to the mean value from high to low.

Table (2): Cont.

| Cross | Trait | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 100-kernel weight | | | grain yield plant$^{-1}$ | | | shelling% | | |
| | N1 | N2 | comb. | N1 | N2 | comb. | N1 | N2 | comb. |
| 1x1 | 25.00 I | 27.00 K | 26.00 K | 83.67KL | 91.17 MN | 87.42 KL | 74.67M | 79.67HI | 77.17K |
| 2x2 | 24.33 I | 28.00 K | 26.17 K | 69.60L | 80.67N | 75.13 L | 84.67DG | 86.33AD | 85.50CD |
| 3x3 | 27.33HI | 32.00 IJ | 29.67 J | 84.83KL | 129.0L | 106.9 IJ | 79.00KL | 79.33HJ | 79.17IJ |
| 4x4 | 30.33H | 35.00 HI | 32.67 I | 126.7 J | 163.0IK | 144.8 H | 68.33N | 71.33K | 69.83M |
| 5x5 | 26.33I | 28.67JK | 27.50 JK | 89.67 KL | 104.7M | 97.17JK | 84.33EH | 83.00EG | 83.67DE |
| 6x6 | 24.00 I | 28.00 K | 26.00 K | 93.90K | 127.0L | 110.4 I | 84.33EH | 86.67AD | 85.50CD |
| 7x7 | 24.67I | 29.00JK | 26.83K | 80.00KL | 107.0 M | 93.50 K | 73.00M | 77.33IJ | 75.17L |
| 1x2 | 35.50FG | 44.50 BC | 40.00CF | 201.8B | 204.0 DF | 202.9 DE | 88.28A | 88.38A | 88.33A |
| 1x3 | 35.50FG | 41.00 CG | 38.25 DG | 197.0 BC | 210.4 CE | 203.7CE | 82.42FJ | 82.58FG | 82.50EG |
| 1x4 | 39.50CF | 41.50 CF | 40.50 CE | 194.6 BD | 239.8 B | 217.2C | 86.64AE | 86.38AD | 86.51AC |
| 1x5 | 34.50 G | 35.00 HI | 34.75 HI | 123.4J | 155.1 K | 139.3H | 81.78HJ | 85.85AE | 83.81DE |
| 1x6 | 44.50 AB | 47.00 B | 45.75 B | 177.9CG | 236.7 B | 207.3CE | 82.72FI | 83.79DG | 83.25E |
| 1x7 | 41.00 BD | 41.00 CG | 41.00 CD | 225.2 A | 238.5 B | 231.8B | 84.85CG | 86.98AB | 85.91BC |
| 2x3 | 36.50 EG | 39.50 DG | 38.00 DG | 195.2 BC | 201.6 DF | 198.4E | 87.56AB | 86.22AD | 86.89AC |
| 2x4 | 37.00 DG | 37.50 FH | 37.25 FH | 194.1 BE | 222.9 BC | 208.5CE | 87.06AD | 84.86BF | 85.96BC |
| 2x5 | 38.50 CG | 39.00 EH | 38.75 DG | 186.6 BF | 241.4 B | 214.0CD | 87.40AC | 86.88AC | 87.14AC |
| 2x6 | 42.00 AC | 43.00 BE | 42.50 C | 169.9 FI | 180.3GJ | 175.1FG | 82.24GJ | 83.86CG | 83.05E |
| 2x7 | 37.50 DG | 38.50 FH | 38.00 DG | 186.5 BF | 215.6 CD | 201.1DE | 88.87A | 87.80AB | 88.34A |
| 3x4 | 36.50 EG | 40.50 CG | 38.50 DG | 172.3EH | 187.3FH | 179.8F | 79.92JL | 81.55GH | 80.73GI |
| 3x5 | 38.00 CG | 39.00 EH | 38.50 DG | 152.9 HI | 194.9EG | 173.9FG | 85.05BF | 79.22HIJ | 82.13EG |
| 3x6 | 37.50 DG | 38.00 FH | 37.75 EG | 161.0GI | 173.0HK | 167.0FG | 78.41L | 76.55J | 77.48JK |
| 3x7 | 36.50 EG | 37.00 GH | 36.75 GH | 157.7 GI | 167.0IK | 162.4G | 83.24FI | 83.02EG | 83.13E |
| 4x5 | 36.50 EG | 39.00 EH | 37.75 EG | 175.7CG | 176.5GJ | 176.1FG | 84.70DG | 81.07GH | 82.88EF |
| 4x6 | 40.50 BE | 43.00 BE | 41.75 C | 148.8 I | 182.2GI | 165.5FG | 81.00IK | 81.09GH | 81.04FH |
| 4x7 | 36.00 EG | 44.00 BC | 40.00 CF | 196.2 BC | 200.7DF | 198.4E | 87.39 AC | 87.64AB | 87.52AB |
| 5x6 | 41.00 BD | 43.50 BD | 42.25 C | 161.0GI | 168.1HK | 164.5 G | 81.11 IK | 77.41IJ | 79.26HJ |
| 5x7 | 37.50 DG | 38.50 FH | 38.00 DG | 172.9DH | 179.3GJ | 176.1FG | 86.42 AE | 85.51AF | 85.97BC |
| 6x7 | 40.50 BE | 44.00 BC | 42.25 C | 126.5 J | 161.9JK | 144.2H | 82.54 FJ | 82.89EG | 82.72EF |
| Pioneer 30K8 | 38.00 CG | 40.00CG | 39 DG | 185.6 BF | 220.5 BC | 203.1 CB | 83.00 FI | 84.5 BF | 83.75 DE |
| Hytech 2031 | 45.50 A | 52.00 A | 48.75 A | 238.5 A | 277.3 A | 257.9 A | 85.01 BF | 86.70AD | 85.86BC |
| Over mean | 35.53 | 38.36 | 36.94 | 154.87 | 177.94 | 166.40 | 82.86 | 83.12 | 82.99 |

**N1, N2 and Comb. refer to first, second nitrogen level and combined analysis, respectively.**
**The capital letters indicate significant difference between means (Duncan test (LSR value, P<0.05).**
**The alphabets descending from A to Z refer to the mean value from high to low.**

For days to 50% maturity, the inbred line $P_5$ at the two nitrogen rates and the combined analysis gave significant lowest value of this trait. On the other hand, none of the hybrids surpassed the late or the highest performing inbred lines and the check hybrid Hytech 2031 except for $P_1xP_3$ revealing that all hybrids were shifted towards the earliness direction. Earliness in maize is favorable for escaping destructive injuries caused by (*Sesamia cretica* ledi), (*Chilo simplex* But) and (*Pyrausta nubilialis*). Similar results were reported by (El-Hosary and El-Badawy, 2005, El-Hosary *et al.* 2006 and Sedhom *et al.*, 2007).

The inbred line No. 1 at low nitrogen rate, No. 4 and 6 at high nitrogen rate and No. 1, 4, 7, 6 and 3 in the combined analysis had significantly the highest mean values for No. of rows ear$^{-1}$. Also, the crosses $P_4xP_6$ in low nitrogen rate, $P_2xP_4$ at high nitrogen rate and $P_4xP_6$, $P_3xP_4$, $P_2xP_4$ and $P_4xP_5$ at the combined analysis gave the highest mean value for this trait and surpassed the check hybrids Hytech 2031 and Pioneer 30K8.

The inbred lines No. 4 and 6 showed significant higher number of kernels row$^{-1}$ at both and across nitrogen rate. The check hybrid Hytech 2031 had the highest number of kernels row$^{-1}$ followed by cross $P_2xP_7$, $P_1xP_7$, $P_2xP_5$ and $P_2xP_4$.

The parental inbred lines No. 4 and 3 gave the highest one for 100-kernel weight. Meanwhile, check hybrid Hytech 2031 exhibited highest weight of 100-kernel followed by P1xP6 at both and across nitrogen rates.

The parental inbred line No. 4 in the first, second nitrogen rate and across them had the highest mean values of grain yield plant$^{-1}$. This inbred line exhibited high mean values for one or more of the traits contributing to grain yield. EL-Badawy *et al.*, 2010 reported that for yield and its component, the parental inbred lines under his study No. 1, 7 and 4 in low nitrogen rate (60 kg N fad.$^{-1}$), 7, 9 and 1 at high nitrogen rate (120 kg N fad.$^{-1}$) and No. 1, 6, 9 and 4 in the combined analysis had the highest mean value s for one or more of the traits contributing to grain yield.

Concerning grain yield plant$^{-1}$ the cross $P_1xP_7$ in low nitrogen rate had a significant superiority over other hybrids and Pioneer 30K8, it insignificant over the check hybrid Hytech 2031. On the same trend, in high nitrogen rate the crosses $P_1xP_4$, $P_1xP_7$, $P_2xP_4$ and $P_2xP_5$ had superiority significantly over check variety Pioneer 30K8. Also, the cross $P_1xP_7$ in the combined analysis gave the highest value for grain yield plant$^{-1}$ compared other hybrids and check variety Pioneer 30K8. These hybrids exhibited significant increase in one or more of traits contributing grain yield (Table 2). The fluctuation of hybrids from nitrogen rate to another was detected for most traits. These results would be due to significant interaction between hybrids and nitrogen rates.

As for shelling %, the parental inbred lines No. 8 in the first nitrogen rate, No. 2 and 6 at high nitrogen rate and No. 2, 6 and 5 at across nitrogen rates had the highest mean values of this trait. On the other hand, the crosses $P_1xP_2$ and $P_2xP_7$ gave significance high values in the combined data.

Such variability among maize genotypes for yield and its components were recorded by several investigators. Among those are: El-Hosary and El-Badawy, 2005; Mosa and Motawei, 2005; Dadheech and Joshi, 2007;

Sedhom *et al.*, 2007, Hefny and Aly, 2008; EL-Badawy *et al.*, 2010 and Hefny, 2011.

**Heterosis**

Heterosis expressed as the percentage deviation of $F_1$ mean performance from Single Cross (S.C.) Hytech 2031 and Pioneer 30K8 values for grain yield plant$^{-1}$ is presented in Table 3. Concerning grain yield plant$^{-1}$ the cross $P_1xP_2$ and $P_1xP_7$ at the low nitrogen level, the parental combination $P_1xP_4$, $P_1xP_6$, $P_1xP_7$ and $P_2xP_5$ at the normal nitrogen level and the hybrid $P_1xP_7$ in the across nitrogen levels, out yielded the check hybrid (Pioneer 30K8). Also, eleven, three and nine hybrids had insignificant heterotic effects relative to the check hybrid (Pioneer 30K8). for low, high nitrogen levels and the combined analysis, respectively. Hance, it could be concluded that these crosses offer possibility for improving grain yield of maize. Also, single cross $P_1xP_7$ did not differ significantly from the hybrid Hytech 2031 in low nitrogen rate and combined analysis for grain yield plant$^{-1}$. While, grain yield plant$^{-1}$ of the single cross $P_2xP_5$ had insignificant heterotic effect in the high nitrogen rate regarding the chick hybrid Hytech 2031. These crosses may be useful for testing under different locations and environments. Several investigators reported high heterosis for yield of maize; i.e. (Shafey *et al.*, 2003; Singh *et al.*, 2004; Kanta *et al.*, 2005; Alamnie *et al.*, 2006; El-Hosary *et al.*, 2006; Hefny, 2007; Sedhom *et al.*, 2007 and EL-Badawy *et al.*, 2010)

**Table 3: Heterosis for grain yield plant$^{-1}$ relative to single crosses Pioneer 30K8 and Hytech 2031.**

| Cross | Heterosis relative to S.C. Pioneer 30K8 | | | Heterosis relative to S.C. Hytech 2031 | | |
|---|---|---|---|---|---|---|
| | N1 | N2 | Comb. | N1 | N2 | Comb. |
| 1x2 | 8.73* | -7.48* | -0.07 | -15.39** | -26.43** | -21.33** |
| 1x3 | 6.14 | -4.58 | 0.32 | -17.40** | -24.13** | -21.02** |
| 1x4 | 4.85 | 8.75** | 6.97 | -18.41** | -13.52* | -15.78** |
| 1x5 | -33.51** | -29.66** | -31.40** | -48.26** | -44.07** | -45.99** |
| 1x6 | -4.15 | 7.35* | 2.09 | -25.41** | -14.64** | -19.62** |
| 1x7 | 21.34** | 8.16** | 14.16** | -5.58 | -13.99** | -10.12 |
| 2x3 | 5.17 | -8.57** | -2.29 | -18.16** | -27.30** | -23.07** |
| 2x4 | 4.58 | 1.09 | 2.68 | -18.62** | -19.62** | -19.15** |
| 2x5 | 0.54 | 9.48** | 5.39 | -21.76** | -12.95 | -17.02** |
| 2x6 | -8.46 | -18.23** | -13.77** | -28.76** | -34.98** | -32.11** |
| 2x7 | 0.48 | -2.22 | -0.96 | -21.80** | -22.25** | -22.02** |
| 3x4 | -7.17 | -15.06** | -11.45** | -27.76** | -32.46** | -30.28** |
| 3x5 | -17.62** | -11.61** | -14.36** | -35.89** | -29.72** | -32.57** |
| 3x6 | -13.25** | -21.54** | -17.75** | -32.49** | -37.61** | -35.25** |
| 3x7 | -15.03** | -24.26** | -20.02** | -33.88** | -39.78** | -37.03** |
| 4x5 | -5.33 | -19.95** | -13.27** | -26.33** | -36.35** | -31.72** |
| 4x6 | -19.83** | -17.37** | -18.49** | -37.61** | -34.29** | -35.83** |
| 4x7 | 5.71 | -8.98** | -2.29 | -17.74** | -27.62** | -23.07** |
| 5x6 | -13.25** | -23.76** | -18.99** | -32.49** | -39.38** | -36.22** |
| 5x7 | -6.84 | -18.68** | -13.27** | -27.51** | -35.34** | -31.72** |
| 6x7 | -31.84** | -26.58** | -28.98** | -46.96** | -41.62** | -44.09** |

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

**N1, N2 and Comb. refer to first, second nitrogen level and combined analysis, respectively.**

**Combining ability**

The analysis of variance for combining ability at the combined analysis for all the studied traits is presented in Table 1. The mean square of general combining ability (GCA) includes the additive and additive x additive genetic portion while specific combining ability (SCA) represents the non additive genetic portion of the total variance arising largely from dominance and epistatic deviations. The mean squares due to general and specific combing ability were significant for all the studied traits, revealing that both additive and non-additive types of gene action were involved in determining the performance of single-cross progeny.

If both general and specific combining ability mean squares are significant, one may ask which type and or types of gene action are important in determining the performance of single- cross progeny. To overcome such situation the size of mean squares can be used to assume the relative importance of general and specific combing ability mean squares which were highly significant. Hence, GCA/SCA ratio was used as measure to reveal the nature of genetic variance involved.

Significant interaction mean squares between nitrogen rates and GCA were detected for all studied traits. Such result indicated that additive and additive by additive effects were more influenced by nitrogen rates than non-additive genetic effects of this trait. Whereas, Significant interaction mean squares between nitrogen rates and SCA were obtained for days to 50% maturity and for shelling%, revealing that non additive effects was more changed with nitrogen rates than additive genetic effects for both traits.

These finding confirm with those obtained above from the ordinary analysis of variance. The interaction between both types of combining abilities and environmental changes were reported to be significant for earliness and grain yield plant$^{-1}$ (Mosa, 2003; El-Badawy, 2006; Mosa and Motawei, 2005; Dadheech and Joshi, 2007; Sedhom *et al.*, 2007 and Hefny and Aly, 2008).

High ratios for GCA/SCA which largely exceeded the unity were obtained for days to 50% maturity, number of rows ear$^{-1}$ and shelling% in both and across nitrogen rates. Indicating that large part of the total genetic variability associated with these traits was additive and additive by additive gene action.

For the other remain traits i.e. No. of kernels row$^{-1}$, 100-kernel weight and grain yield plant$^{-1}$, GCA/SCA ratios, were less than unity. Therefore, it could be concluded that the large portion of the total genetic variability associated with these traits is due to non-additive gene action. Similar results were reported by (Amer, 2005, El-Hosary and El-Badawy, 2005, El-Hosary *et al.*, 2006 and Sedhom *et al.*, 2007). On the other hand, Iqbal *et al.*, (2007; Akbar *et al.*, (2008) and Hefny (2010) reported that both additive and non additive were important in the genetic expression of most of the traits studied in maize.

It is fairly evident that ratio for GCAxN/GCA was higher than ratio of SCAxN/SCA for shelling%. Also, the interaction of GCAxN were significant for No. of rows ear$^{-1}$, No of kernel row$^{-1}$, 100-kernel weight and grain yield plant$^{-1}$ but insignificant SCAxN were detected. This result indicated that additive effects were more influenced by nitrogen rates than non additive genetic effects of these traits. For days to 50% to maturity indicating that the non-additive effects were more influenced by nitrogen rates than additive genetic effects. This conclusion is in well agreement with those reported by Gilbert (1958).

**General combining ability effects**

Estimates of GCA effects ($\hat{g}_i$) for individual parental inbred lines for each trait in the combined analysis are presented in Table 4.general combining ability effects estimated herein differ significantly from zero as it compared to LSD values at 0.05 and 0.01 level of significance. High positive values would be of interest under all traits in question except days to 50% maturity where high negative effects would be useful from the breeder's point of view.

The parental inbred line No. 5 exhibited significant negative ($\hat{g}_i$) effects for; days to 50% maturity at both and across nitrogen rates indicating that this inbred line could be considered as a good combiner for developing early genotypes to escape corn pests. The parental inbred line No. 2 was a good combiner for No. of kernels row$^{-1}$ at high nitrogen rate as well as the combined analysis and for shelling % at both and across nitrogen rates. The parental inbred line No. 4 seemed to be a good combiner for No. of rows ear$^{-1}$ and grain yield plant$^{-1}$ at both and across nitrogen rate, for No. of kernels row$^{-1}$ at low nitrogen rate and 100- kernel weight at high nitrogen rate as well as the combined analysis. The parental inbred line No. 6 exhibited significant positive ($\hat{g}_i$) effects for; 100-kernel weight. Sofi and Rather, 2006 found that the parents, CML-244, CML-79 and CML-214; GLET-27; CML-214, W-7 and CML-244 and CML-214, W-6 and CMl-111 were good general combiners for grain yield plant$^{-1}$; 100-kernel weight; kernel row ear-$^{1}$ and ear length, respectively.

**Table 4. General combining ability effects for parents for each Nitrogen level as well as the combined across them for all traits under study.**

| Parent | Trait | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | days to maturity | | | no of rows ear$^{-1}$ | | | no of kernels row$^{-1}$ | | |
| | N1 | N2 | Comb | N1 | N2 | Comb | N1 | N2 | Comb |
| P1 | 1.09** | 1.70** | 1.40** | 0.16 | -0.29** | -0.07 | 0.13 | -0.25 | -0.06 |
| P2 | -0.90** | -1.54** | -1.22** | -0.30* | -0.22* | -0.26* | 0.68 | 1.54** | 1.11** |
| P3 | 0.10 | 0.65** | 0.37* | -0.05 | 0.12 | 0.03 | -1.41** | -0.43 | -0.92* |
| P4 | -1.04** | -1.45** | -1.25** | 1.45** | 1.19** | 1.32** | 1.34** | -0.17 | 0.58 |
| P5 | -1.89** | -3.34** | -2.61** | -0.47** | -0.28** | -0.37** | 0.31 | -0.26 | 0.03 |
| P6 | 0.88** | 1.35** | 1.11** | -0.31* | -0.11 | -0.21 | -1.16** | -1.13** | -1.14** |
| P7 | 1.76** | 2.64** | 2.20** | -0.47** | -0.42** | -0.44** | 0.11 | 0.70* | 0.40 |
| LSD gi 5% | 0.27 | 0.30 | 0.28 | 0.28 | 0.20 | 0.24 | 0.80 | 0.66 | 0.73 |
| LSD gi 1% | 0.36 | 0.40 | 0.38 | 0.37 | 0.27 | 0.32 | 1.06 | 0.88 | 0.97 |
| LSD (gi-gj) 5% | 0.41 | 0.46 | 0.43 | 0.42 | 0.31 | 0.36 | 1.22 | 1.01 | 1.11 |
| LSD (gi-gj) 1% | 0.54 | 0.61 | 0.58 | 0.56 | 0.41 | 0.48 | 1.62 | 1.34 | 1.48 |

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

**N1, N2 and Comb. refer to first, second nitrogen level and combined analysis, respectively.**

**Table 4: Cont.**

| Parent | Trait | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 100-kernel weight | | | grain yield plant$^{-1}$ | | | shelling% | | |
| | N1 | N2 | Comb | N1 | N2 | Comb | N1 | N2 | Comb |
| P1 | -0.09 | 0.07 | -0.01 | 6.34** | 6.16** | 6.25** | -0.69** | 1.06** | 0.18 |
| P2 | -0.62 | -0.59 | -0.61 | 4.80* | 1.77 | 3.28 | 3.16** | 2.99** | 3.08** |
| P3 | -0.68 | -0.48 | -0.58 | -2.71 | -2.14 | -2.42 | -0.85** | -1.77** | -1.31** |
| P4 | 0.60 | 1.35** | 0.97* | 11.66** | 13.79** | 12.72** | -2.10** | -2.06** | -2.08** |
| P5 | -0.29 | -1.33** | -0.81* | -8.70** | -9.63** | -9.17** | 1.43** | -0.20 | 0.61* |
| P6 | 1.41** | 1.24** | 1.33** | -10.81** | -6.13** | -8.47** | -0.62* | -0.54 | -0.58* |
| P7 | -0.33 | -0.26 | -0.29 | -0.57 | -3.82* | -2.19 | -0.33 | 0.53 | 0.10 |
| LSD gi 5% | 0.82 | 0.79 | 0.81 | 4.17 | 3.66 | 3.91 | 0.50 | 0.56 | 0.53 |
| LSD gi 1% | 1.09 | 1.05 | 1.07 | 5.55 | 4.86 | 5.20 | 0.66 | 0.75 | 0.71 |
| LSD (gi-gj) 5% | 1.25 | 1.21 | 1.23 | 6.37 | 5.58 | 5.98 | 0.76 | 0.86 | 0.81 |
| LSD (gi-gj) 1% | 1.67 | 1.60 | 1.64 | 8.47 | 7.43 | 7.95 | 1.02 | 1.14 | 1.08 |

*** and ** significant at 0.05 and 0.01 levels of probability, respectively.**
**N1, N2 and Comb. refer to first, second nitrogen level and combined analysis, respectively.**

These result indicated that these parental inbred lines possess favorable genes and that improvement in yield may be attained if they are used in hybridization program.

**Specific combining ability**

Specific combining ability effects $\hat{S}_{ij}$ for the studied 21 hybrids were computed for all the studied traits (Table 5).

**Table 5: Specific combining ability effects for all the studied traits at two nitrogen levels as well as the combined across them.**

| Cross | Trait | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | days to maturity | | | no of rows ear$^{-1}$ | | | no of kernels row$^{-1}$ | | |
| | N1 | N2 | Comb | N1 | N2 | Comb | N1 | N2 | Comb |
| 1x2 | -1.60* | -1.59 | -1.59 | -0.49 | 0.60 | 0.06 | 2.26 | 4.85* | 3.55 |
| 1x3 | 0.30 | 0.79 | 0.54 | 0.02 | 0.50 | 0.26 | 4.60 | 1.78 | 3.19 |
| 1x4 | -0.99 | -1.34 | -1.17 | 0.32 | -0.12 | 0.10 | 3.22 | 3.13 | 3.17 |
| 1x5 | -1.55 | -1.45 | -1.50 | 0.23 | -0.26 | -0.01 | -2.84 | -1.99 | -2.42 |
| 1x6 | 0.09 | 0.35 | 0.22 | -0.13 | -0.08 | -0.10 | 3.72 | 1.78 | 2.75 |
| 1x7 | 1.14 | 0.90 | 1.02 | -0.36 | 0.65 | 0.14 | 7.98* | 5.56* | 6.77* |
| 2x3 | -1.54 | -1.53 | -1.54 | 1.97* | 0.48 | 1.22 | 1.13 | 3.59 | 2.36 |
| 2x4 | 0.22 | -0.43 | -0.11 | 0.17 | 2.31** | 1.24 | 2.91 | 4.33* | 3.62 |
| 2x5 | 2.25* | 0.45 | 1.35 | 0.62 | 0.01 | 0.31 | 5.68* | 4.32* | 5.00* |
| 2x6 | 1.91* | 0.50 | 1.21 | 0.13 | 0.45 | 0.29 | -0.22 | 0.72 | 0.25 |
| 2x7 | 0.70 | -0.69 | 0.00 | 0.49 | 0.01 | 0.25 | 5.51* | 6.86** | 6.19* |
| 3x4 | -0.60 | -0.62 | -0.61 | 1.53 | 0.97 | 1.25 | -2.23 | -4.32* | -3.28 |
| 3x5 | 0.64 | -1.40 | -0.38 | -0.63 | 0.44 | -0.09 | 2.93 | 5.49* | 4.21 |
| 3x6 | -0.66 | -0.09 | -0.37 | 0.29 | 0.06 | 0.18 | 0.47 | 0.11 | 0.29 |
| 3x7 | -2.04* | -2.38* | -2.21* | 0.50 | -0.73 | -0.11 | -0.20 | 1.23 | 0.52 |
| 4x5 | 0.79 | 0.04 | 0.41 | 1.74* | 0.97 | 1.35 | 0.65 | 2.15 | 1.40 |
| 4x6 | 1.28 | 0.68 | 0.98 | 2.38* | 0.80 | 1.59* | -0.98 | -4.60* | -2.79 |
| 4x7 | 1.82* | 1.39 | 1.60 | 1.55 | -0.39 | 0.58 | 2.45 | 1.27 | 1.86 |
| 5x6 | 0.66 | 0.57 | 0.62 | -0.60 | 0.36 | -0.12 | -1.95 | -2.37 | -2.16 |
| 5x7 | 0.61 | 0.61 | 0.61 | -0.14 | 0.22 | 0.04 | 3.03 | 1.96 | 2.50 |
| 6x7 | -3.82** | -2.42* | -3.12** | -1.70* | -0.10 | -0.90 | -1.95 | 1.73 | -0.11 |
| LSD 5% Sij | 1.56 | 1.76 | 1.66 | 1.61 | 1.16 | 1.39 | 4.63 | 3.84 | 4.23 |
| LSD 1% Sij | 2.76 | 3.10 | 2.93 | 2.85 | 2.06 | 2.46 | 8.19 | 6.81 | 7.50 |
| LSD 5% Sij-Sik | 2.31 | 2.61 | 2.46 | 2.39 | 1.73 | 2.06 | 6.88 | 5.70 | 6.29 |
| LSD 1% Sij-Sik | 4.10 | 4.61 | 4.36 | 4.23 | 3.07 | 3.65 | 12.16 | 10.12 | 11.14 |
| LSD 5% Sij-Skl | 2.16 | 2.44 | 2.30 | 2.24 | 1.62 | 1.93 | 6.43 | 5.33 | 5.88 |
| LSD 1% Sij-Skl | 3.84 | 4.31 | 4.08 | 3.96 | 2.87 | 3.41 | 11.38 | 9.47 | 10.42 |

*** and ** significant at 0.05 and 0.01 levels of probability, respectively.**
**N1, N2 and Comb. refer to first, second nitrogen level and combined analysis, respectively.**

**Table 5: Cont.**

| | Trait | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 100-kernel weight | | | grain yield plant$^{-1}$ | | | shelling% | | |
| Cross | N1 | N2 | Comb | N1 | N2 | Comb | N1 | N2 | Comb |
| 1x2 | 1.05 | 7.10* | 4.08 | 36.85* | 19.66 | 28.25* | 3.03* | 1.36 | 2.19 |
| 1x3 | 1.11 | 3.49 | 2.30 | 39.60* | 29.93* | 34.77* | 1.18 | 0.32 | 0.75 |
| 1x4 | 3.83 | 2.16 | 2.99 | 22.84 | 43.44** | 33.14* | 6.65** | 4.41* | 5.53** |
| 1x5 | -0.28 | -1.66 | -0.97 | -28.01* | -17.84 | -22.92* | -1.74 | 2.02 | 0.14 |
| 1x6 | 8.01* | 7.77* | 7.89* | 28.58* | 60.25** | 44.42** | 1.25 | 0.30 | 0.77 |
| 1x7 | 6.25* | 3.27 | 4.76* | 65.69** | 59.70** | 62.69** | 3.09* | 2.42 | 2.76 |
| 2x3 | 2.64 | 2.66 | 2.65 | 39.34* | 25.55* | 32.45* | 2.47 | 2.03 | 2.25 |
| 2x4 | 1.87 | -1.18 | 0.34 | 23.91 | 30.98* | 27.45* | 3.21* | 0.95 | 2.08 |
| 2x5 | 4.25 | 3.01 | 3.63 | 36.77* | 72.90** | 54.83** | 0.03 | 1.13 | 0.58 |
| 2x6 | 6.05* | 4.44 | 5.24* | 22.15 | 8.20 | 15.17 | -3.09* | -1.56 | -2.32 |
| 2x7 | 3.29 | 1.44 | 2.36 | 28.51* | 41.28** | 34.89* | 3.25* | 1.32 | 2.28 |
| 3x4 | 1.42 | 1.71 | 1.57 | 9.58 | -0.82 | 4.38 | 0.09 | 2.41 | 1.25 |
| 3x5 | 3.81 | 2.90 | 3.35 | 10.57 | 30.23* | 20.40 | 1.69 | -1.77 | -0.04 |
| 3x6 | 1.61 | -0.68 | 0.47 | 20.75 | 4.85 | 12.80 | -2.90 | -4.11* | -3.51* |
| 3x7 | 2.35 | -0.18 | 1.09 | 7.21 | -3.46 | 1.87 | 1.64 | 1.30 | 1.47 |
| 4x5 | 1.03 | 1.06 | 1.05 | 18.97 | -4.07 | 7.45 | 2.58 | 0.36 | 1.47 |
| 4x6 | 3.33 | 2.49 | 2.91 | -5.81 | -1.87 | -3.84 | 0.94 | 0.71 | 0.82 |
| 4x7 | 0.57 | 4.99* | 2.78 | 31.34* | 14.32 | 22.83* | 7.04** | 6.20** | 6.62** |
| 5x6 | 4.72 | 5.68* | 5.20* | 26.72* | 7.45 | 17.08 | -2.48 | -4.82* | -3.65* |
| 5x7 | 2.96 | 2.18 | 2.57 | 28.40* | 16.29 | 22.34 | 2.54 | 2.22 | 2.38 |
| 6x7 | 4.25 | 5.10* | 4.68 | -15.89 | -4.57 | -10.23 | 0.71 | -0.07 | 0.32 |
| LSD 5% Sij | 4.77 | 4.59 | 4.68 | 24.26 | 21.26 | 22.76 | 2.91 | 3.27 | 3.09 |
| LSD 1% Sij | 8.45 | 8.16 | 8.30 | 42.91 | 37.74 | 40.33 | 5.14 | 5.80 | 5.47 |
| LSD 5% Sij-Sik | 7.09 | 6.83 | 6.96 | 36.04 | 31.59 | 33.81 | 4.32 | 4.85 | 4.59 |
| LSD 1% Sij-Sik | 12.55 | 12.12 | 12.33 | 63.75 | 56.07 | 59.91 | 7.64 | 8.61 | 8.13 |
| LSD 5% Sij-Skl | 6.63 | 6.38 | 6.51 | 33.71 | 29.55 | 31.63 | 4.04 | 4.54 | 4.29 |
| LSD 1% Sij-Skl | 11.74 | 11.33 | 11.53 | 59.63 | 52.45 | 56.04 | 7.15 | 8.06 | 7.60 |

*** and ** significant at 0.05 and 0.01 levels of probability, respectively.**
**N1, N2 and Comb. refer to first, second nitrogen level and combined analysis, respectively.**

Significant SCA effects for different hybrids were detected based on the values of Least Significant Difference (LSD) at both 0.05 and 0.01 levels of significant. The most desirable inter and intra allelic interactions were presented by combinations: $P_3xP_7$ and $P_6xP_7$ for days to 50% maturity, $P_4xP_6$ for number of rows ear$^{-1}$, $P_1xP_7$, $P_2xP_5$ and $P_2xP_7$ for No. of kernels row$^{-1}$, $P_1xP_6$, $P_1xP_7$, $P_2xP_6$ and $P_5xP_6$ for 100-kernel weight, $P_1xP_2$, $P_1xP_4$, $P_1xP_6$, $P_1xP_7$, $P_2xP_3$, $P_2xP_5$, $P_2xP_7$ and $P_4xP_7$ for grain yield plant$^{-1}$ and $P_1xP_4$ and $P_4xP_7$ for shelling%. These crosses may be prime importance in breeding programs either towards hybrid maize production or synthetic varieties composed of hybrids which involved the good combiners for the traits in view.

## CONCLUSION

This study clarified that the single crosses $P_1xP_2$ and $P_1xP_7$ at the low nitrogen level, $P_1xP_4$, $P_1xP_6$, $P_1xP_7$ and $P_2xP_5$ hybrids at the normal nitrogen level and the hybrid $P_1xP_7$ in the combined analysis were out yielded the check hybrid (Single cross S.C. Pioneer 30K8). Hance, it could be concluded that these crosses offer possibility for improving grain yield of maize. Also, single cross $P_1xP_7$ did not differ significantly from the hybrid Hytech 2031 in low nitrogen rate and combined analysis for grain yield plant$^{-1}$. While, grain yield plant$^{-1}$ of the single cross $P_2xP_5$ had insignificant heterotic effect in the high nitrogen rate regarding the chick hybrid Hytech 2031. These crosses may be useful for testing under different locations and environments. The parental inbred line No. 4 gave a good combiner for No. of rows ear$^{-1}$ and grain yield plant$^{-1}$ at both and across nitrogen rate. The best SCA effects for grain yield$^{-1}$ plant were presented by combinations $P_1xP_2$, $P_1xP_4$, $P_1xP_6$, $P_1xP_7$, $P_2xP_3$, $P_2xP_5$, $P_2xP_7$ and $P_4xP_7$. These crosses may be prime importance in breeding programs either towards hybrid maize production or synthetic varieties composed of hybrids which involved the good combiners for the traits in view.

## RECOMMENDATION

From the previous results it is recommended that the single cross $P_1$ x $P_7$ expressed the highest seed yield as compared to all studied crosses and the check hybrid (Pioneer 30K8) and insignificant hetoretic effect regarding the chick hybrid Hytech 2031. This particular hybrid had a practical value and could be used as a promising single cross in maize.

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# قوة الهجين والقدرة علي التألف في الذرة الشامية بأستخدام الهجن التبادلية بين سبع سلالات جديدة

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أجرى تقييم الهجن الناتجة من التهجين النصف دائري لسبع سلالات من الذرة البيضاء تحت مستويين من التسميد الازوتى (٦٠ و ١٢٠ كجم نيتروجين/ فدان) لستة صفات كمية هي ميعاد النضج وعدد الصفوف للكوز وعدد الحبوب للصف ووزن المائة حبة ومحصول الحبوب للنبات و نسبة التصافي في تصميم قطاعات كاملة العشوائية في مزرعة مركز البحوث والتجارب بكلية الزراعة بمشتهر جامعة بنها.

كانت متوسطات التباين لكل من مستويات التسميد والتراكيب الوراثية والآباء والهجن معنوية في كل الصفات تحت الدراسة. كما كان متوسط التباين للتفاعل بين التراكيب الوراثية ومعدلات التسميد معنوي لصفة ميعاد النضج وعدد الصفوف للكوز ونسبة التصافي. كما أظهر متوسط التباين للتفاعل بين الهجن ومعدلات التسميد معنوية لصفات ميعاد النضج وعدد الصفوف للكوز ومحصول الحبوب للنبات. و كانت التباينات للقدرة العامة والخاصة على التآلف معنوية لكل الصفات تحت الدراسة. وكانت النسبة بين القدرة العامة والقدرة الخاصة أكبر من الوحدة لكل من صفة ميعاد النضج وعدد الصفوف للكوز ونسبة التصافي في كلا من مستويى التسميد و التحليل التجميعي. وكان متوسط التباين للتفاعل بين مستويى التسميد والقدرة العامة والخاصة معنويا لمعظم الصفات تحت الدراسة. أظهرت الهجن الأتية (٢x١ و ١ x ٧) لمستوي التسميد النتروجيني المنخفض والهجن (١ x ٤ ، ١ x ٦ ، ١ x ٧ و ٢ x ٥) لمستوي النتروجين العالي والهجين (١ x ٧ ) لكلا من مستويي التسميد والتحليل التجميعي تفوقا واضح ومعنوي في قوة الهجين للمحصول عن الهجين الفردي المقارن بيونير ٣٠ك٨. كما أظهر الهجين (١ x ٧) انه لم يختلف معنوياً عن الصنف المقارن هايتك ٢٠٣١ فى قوة الهجين لمحصول حبوب النبات عند التسميد المنخفض و التحليل المشترك. أظهرت السلالة الأبوية الرابعة قدرة عامة علي التوافق جيدة ومرغوبة لصفة عدد صفوف الكوز ومحصول الحبوب للنبات. كما أوضحت الهجن (١ x ٦ ، ١ x ٧ ، ٢ x ٦ و ٥ x ٦ ) قدرة خاصة ومرغوبة علي التآلف لصفة وزن المائة حبة والهجن (١ x ٢ ، ١ x ٤ ، ١ x ٦ ، ١ x ٧، ٢ x ٣ ، ٢ x ٥ ، ٢ x ٧ و ٤ x ٧ ) لصفة محصول الحبوب للنبات والهجن (١ x ٤ و ٤ x ٧ ) لصفة نسبة أو معدل التصافي. وهذه الهجن يمكن أن يكون لها أهمية في برامج التربية وخصوصا في انتاج الهجن الفردية والهجن التركيبية للصفات تحت الدراسة.

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