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# PRINCIPAL COMPONENT AND RESPONSE CURVE ANALYSES OF SOME MAIZE HYBRIDS TO DIFFERENT NITROGEN FERTILIZATION LEVELS AND PLANT DENSITY

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## ABSTRACT

Two field experiments were carried out at Gemmiza Agricultural Research Station during the two successive growing seasons of 2001 and 2002. The relationship between grain yield and its components was investigated. Yielding ability of four maize hybrids, two of them are white [single cross 10 (S. C. 10) and three way cross 325 (T. W. C. 325)] and the other two are yellow [single cross 129(S. C. 129) and three way cross 352(T. W. C. 352)]. Nitrogen fertilization levels (0, 40, 80, 120 and 160 Kg N / fed) and plant densities (20000, 24000 and 30000 plants / fed) effect on yield were studied. Principal component analysis, fitting polynomial curve techniques as well as performing economic analysis of the response curve were utilized. Results obtained show that:

1- Single cross 10 significantly surpassed single cross 129, three way cross 325 and three way cross 352 for ear length, number of kernels / row, 100 – kernel weight, grain yield per plant and per feddan and ear height. Three way cross 325 gave the tallest plants. While ,three way cross 352 had the highest ear diameter and number of rows / ear.

2- Planting maize at 24000 plants / fed significantly increased all studied characters except,plant and ear height,the number of rows / ear and shelling %. 24000 plants / fed recorded the highest yield being 24.38 ard / fed, whereas 30000 plants / fed gave the lowest.
3- Increasing nitrogen level up to 120 kg N / fed increased grain yield of maize and its components. The highest grain yield / fed (32.09 ard / fed) increased up to 135.09 % of unfertilized maize by adding 120 kg N / fed.
4- Ear diameter, ear length, the number of kernels / row, 100 kernel weight, grain yield / plant and grain yield / fed were significantly affected by the $1^{st}$ order interaction (plant density X nitrogen level). Also grain yield per plant and per fed were affected by (hybrids X nitrogen level), whereas the $1^{st}$ order interaction of hybrids X plant density and the $2^{nd}$ interaction order hybrids, plant density and nitrogen level did not significantly affect all studied characters.

   The results generally show that growing single cross 10 at 24000 plants / fed and adding 120 kg N / fed produced high grain yield.
5- The results indicate positive and highly significant correlation coefficients between grain yield / plant and its components except the number of rows / ear.
6- The principal component analysis grouped the studied variables in two major components, which alltogether accounted for 95.6 % of the total variation. The first component included ear diameter, ear length, the number of kernels / row, 100 – kernel weight, shelling % and grain yield / plant. The second component included plant and ear heights and the number of rows / ear.
7- Maize grain yield significantly responded to nitrogen fertilization and that response was quadratic. It gives the highest value for coefficient of determination ($R^2$), and the lowest value of standard error (SE) compared with linear response under the three population densities. The optimum nitrogen rate ranged from 103 kg N / fed to 111 kg N / fed. Grain yield at the optimum N dose ranged from 26 ard / fed to 31 ard / fed and the monetary return ranged from 2686 to 3286 £E / fed.

***Key words****:curve analysis. maize hybrids, net profit, plant density,principal component,.*

## 1. INTRODUCTION

The ever increasing pressure of population has challenged the Egyptians to increase production per unit area due to lionitation of fertile land. Two ways are possible to realize this strategy, *i. e.* to release new high yielding cultivars and to develop more adequate cultural packages. Therefore, studies on plant nutritional requirements must continue with the concomitant release of new cultivars and soil fertility development.

Cultural treatments play an important role in increasing maize production. Population density, N fertilizer level are considered among the most important factors affecting maize yield. Some growth and agronomic characters *i.e.* plant and ear height were reduced by increasing plant density, El-Douby (1987), El-Hossary and Salwau (1989), El-Deeb (1990), Matta *et al.* (1990) and Badr *et al.* (1993). Several investigations showed that yield components such as ear length, ear diameter, and the number of kernels / row significantly decreased by increasing plant density, Badr *et al.* (1993), El-Sheikh (1993), Basha (1994), El-Gezawy (1996), Shams El-Din and El-Habbak (1996) and El-Douby *et al.* (2001) . On the other hand, El-Douby (1987), El-Hossary and Salwau (1989) and Salwau (1993), found that the number of rows / ear and shelling percentage were not influenced by increasing plant density. Grain yield of maize was significantly increased by increasing plant population up to 24000 plants / fed, (El-Gezawy ,1996; Shams El-Din and El-Habbak, 1996).

Some growth and agronomic characters such as plant and ear heights, were affected by application of N fertilizer (El-Sheikh, 1993; Basha, 1994; El-Gezawy, 1996 and Shams El-Din and El-Habbak, 1996). Also, most yield and yield component characters of maize, were significantly affected by increasing N fertilizer level up 130 or 150 kg N / fed, while the number of rows / ear was affected by adding N fertilizer (El-Hossary and Salwau, 1989; El-Deeb, 1990; Matta *et al.*, 1990; Salwau, 1993; Moshtohory *et al.*, 1995; El-Gezawy, 1996; El-Douby *et al.*, 2001, Mohamed *et al.*, 2002 and Carlos Costa *et al.*, 2002).

A direct relationship between N fertilization rate and maize grain yield has been widely demonstrated (Zhang *et al.*, 1993; Jokela and Randall, 1989; McCullough *et al.*, 1994 and Carlos Costa *et al.*, *2002*). However, studies with conventional maize hybrids (Chevalier and Schrader, 1977; Perez Leroux and Long, 1994, Mohamed *et al*., 2002) had shown that maize genotypes vary in their response to N availability, reflecting variations in their relative abilities to absorb N from the soil (N uptake efficiency), and in their relative efficiencies in using acquired N to produce yield components (N use efficiency) (Chevalier and Schrader, 1977; Moll *et al*., 1982). In addition, there is a growing public awareness of N as a source of pollution of agroecosystems. This has led N to being targeted for study both as a plant nutrient (Rice *et al*., 1995) and as a pollutant (Gaines and Gaines, 1994; and Patni *et al*., 1996).

Decisions concerning optimal levels of fertilization involve some types of model to the yield data collected when several rates of fertilizer are applied. Balko and Russel (1980), Cerrato and Blackmer, (1990); Fox and Piekielek, (1983); Ashmawy (1995) and El-Douby *et al*., (2001) studied the response of maize yield to nitrogen fertilizer. They found that the response of maize yield to nitrogen was quadratic.

The objective of this study was to compare yielding ability of local maize hybrids as affected by N-fertilization levels and plant densities to determine the dependence relationship between yield components in maize.

## 2. MATERIALS AND METHODS

Two field experiments were conducted at the Agricultural Research Station of Gemmeiza in the 2001 and 2002 summer growing seasons to compare the yielding ability of four maize hybrids, namely ,single crosses 10, and 129, three way crosses 325 and cross 352 as affected by N fertilization levels (0, 40, 80, 120 and 160 Kg N / fed.) and three plant densities (20000, 24000, and 30000 plant / fed). The treatments were assigned in split split - plot design with three replications. Hybrids were arranged at random in the main plots, plant population densities were allocated to the sub – plots while levels of N – fertilizer occupied the sub – sub plots. The experimental plot area was 10.5 $m^2$, consisting of 5 ridges, 3m long and 70.0 cm wide. Chemical and mechanical analyses of the soil of the experiments are presented in Table (1).

**Table (1): Average mechanical and chemical analyses for the soil in two growing seasons at the experimental area.**

| Mechanical analysis | Values | Chemical analysis | Values |
|---|---|---|---|
| Sand % | 17.5 | Soil reaction pH | 7.7 |
| Silt % | 34.6 | Organic matter % | 1.94 |
| Clay % | 45.4 | Available nitrogen(ppm) | 34.15 |
| Soil texture | Clay | Available phosphorus(ppm) | 7.10 |
| | | Available potassium(ppm) | 44.0 |

The preceding crop was wheat in both seasons. Maize hybrids were planted in hills 20, 25 and 30 cm apart to give 30000, 24000 and 20000 plants / fed. Nitrogen fertilization was given in the form of ammonium nitrate (33.5 % N) at two equal doses before the first and second irrigations. The normal cultural practices were carried out as recommended.

Random samples of 10 plants and 10 ears were taken from sub sub – plots at harvesting time to determine the following characters: plant height (cm), ear height (cm), ear diameter (cm), ear length (cm), number of rows / ear, number of kernels / row, 100 – kernel weight, shelling %, grain yield / plant and grain yield (ard / fed).

A single analysis of variance was done for the data of each season separately and combined analysis was performed to the data over the two seasons according to Snedecor and Cochran (1980) and treatment means were compared by least significant difference test (L. S. D.) at 0.05 level of significance.

Simple and multiple correlation coefficients and coefficient of determination were computed between the above mentioned characters as outlined by Steel and Torrie (1987). Principal component analysis as applied by Berenson *et al.* (1983) aims to account for the total variation of these n subjects in p dimensional space by forming a new set of orthogonal and uncorrelated composite varieties. Thus, each member of the new set of varieties is a linear combination of the original set of measurements.

To study maize yield response to nitrogen fertilizer, two response models namely: linear and quadratic were fitted to the data of grain yield / fed for the four tested hybrids over the two seasons according to Neter *et al.* (1990).

Linear model is given using the formula:

$$Y = a + bx$$

Quadratic polynomial model is estimated by using the formula:

$$Y = a + bx + cx^2$$

Where Y = is the grain yield ard. / fed.

a = is the Y intercept.

b = is the linear coefficient of regression.

x = is the level of nitrogen fertilizer applied in kg / fed.

c = the quadratic coefficient of regression.

Comparison among the two models was based on three bases *i.e.* coefficient of determination ($R^2$), standard error of estimate (SE) and the model significance. The significant model that had the highest ($R^2$) and the lowest (SE) was the best model fitted to the yield data.

The economic techniques used to determine the optimum rates of fertilizer depend partly on the model used to fit the data. The economic optimum fertilizer rates also depend directly on the price of the fertilizer and the selling price of the grains.

For a single variable model being fitted to the data from a single site - year, the optimal rate will be obtained by optimizing the total profit equation (Engelstat, 1985 and Dillon and Anderson, 1990). In this case since we are fixing the levels of all other factors throughout all experimental plots, then the total profit equation represents returns for those fixed factors. Calculus techniques are then used to maximize total profit. The total profit equation is:

$$\pi = p_Y f(X) - p_X X$$

where $\pi$ : is the amount of profit.

$p_Y$ : is the price of product.

$p_X$ : is the price of input (in this case nitrogen).

$X$ : is the level of input (in this case nitrogen).

$f(X)$: is the production function.

By taking the first derivative of the above profit equation with respect to X and equating that to zero:

$$\delta \pi / \delta X = p_Y \delta f(X) / \delta X - p_X = 0$$

which can be written as:

$$p_Y \delta f(X) / \delta X = p_X$$

This gives the first order condition of profit maximization, which says that the marginal value of the product should equal the fertilizer price at the optimum rate. Solving this first order condition for the level of X (the only unknown) gives the optimum nitrogen level. In other words, the farmer would continue increasing nitrogen until the returns from the last unit added is just equal to that unit's price.

The price of ammonium nitrate, as a source of nitrogen used in this study, and the price of maize grains considered for the economic analysis were those prevailing in Egypt during 2002 *i.e* £E 1.522 / kg for nitrogen and £E 110 / ard for maize grains according to the Agricultural Credit Bank,(2002).

## 3. RESULTS AND DISCUSSION

Means of grain yield of maize and its components as affected by hybrids,plant density and nitrogen levels are presented inTable (2).

### 3.1. Hybrid effect

Four maize hybrids were tested in the present study. There were highly significant differences among all studied characters indicating genetic variation for these traits and response of each to the environmental conditions during the growing season. The results clearly showed that the single cross 10 gave the highest values for ear length, the number of kernels per row, 100-kernel weight, and grain yield per plant and per feddan being 19.52 cm, 44.78, 38.56 gm, 252.5 gm and 23.81 ard / fed, respectively. Concerning plant height the three way cross 325 ranked first where it gave the tallest plants (294.7 cm). Single cross 10 recorded the highest ear height being (142.3 cm). Three way cross 352 resulted in the greatest ear diameter and highest number of rows / ear recording 5.058 cm and 15.47, respectively. These findings are in agreement with those reported by Mohamed *et al*. (2002).

### 3.2. Effect of plant density

The results in Table (2) reveal that maize performance was significantly affected by increasing plant density up to 24000 plants / fed in all the studied characters, except plant and ear heights, the number of rows / ear and shelling percentage. The results clearly indicated that maize planted at 24000 plants / fed gave the highest

**Table (2): Means of grain yield and its components as affected by maize hybrid, plant density and nitrogen level in 2001and 2002 and their combined analysis.**

| Characters | Plant height (cm) | | | Ear height (cm) | | | Ear diameter (cm) | | |
|---|---|---|---|---|---|---|---|---|---|
| Treatments | 2001 | 2002 | Comb. | 2001 | 2002 | Comb. | 2001 | 2002 | Comb. |
| Hybrids(H): | | | | | | | | | |
| 1-Single cross 10 | 255.1 | 304.7 | 279.9 | 137.8 | 146.8 | 142.3 | 4.767 | 5.056 | 4.911 |
| 2- Single cross 129 | 2 47.0 | 301.4 | 274.2 | 132.2 | 137.1 | 134.7 | 4.629 | 5.018 | 4.823 |
| 3- Three way cross 325 | 287.9 | 301.5 | 294.7 | 135.8 | 140.6 | 138.2 | 4.691 | 5.116 | 4.903 |
| 4- Three way cross 352 | 261.1 | 282.8 | 272.0 | 141.2 | 133.9 | 137.5 | 5.056 | 5.060 | 5.058 |
| L. S. D. (5%) | 5.683 | 8.823 | 5.220 | 5.880 | 5.030 | 3.850 | 0.107 | 0.099 | 0.073 |
| Plant density (D): | | | | | | | | | |
| 1- 30000 plant/fed | 263.1 | 293.9 | 278.5 | 137.4 | 137.5 | 137.4 | 4.700 | 5.055 | 4.877 |
| 2- 24000 plant/fed | 264.6 | 301.9 | 283.3 | 138.1 | 141.0 | 139.5 | 4.877 | 5.082 | 4.979 |
| 3- 20000 plant/fed | 260.6 | 297.1 | 278.8 | 134.7 | 140.3 | 137.5 | 4.780 | 5.050 | 4.915 |
| L. S. D. (5%) | - | - | - | - | - | - | 0.128 | 0.020 | 0.054 |
| Nitrogen levels (N) | | | | | | | | | |
| 0 Kg N/fed | 274.0 | 289.2 | 281.6 | 140.4 | 134.7 | 137.5 | 4.342 | 4.844 | 4.593 |
| 40 Kg N/fed | 260.8 | 293.6 | 277.2 | 134.3 | 137.5 | 135.9 | 4.647 | 4.961 | 4.804 |
| 80 Kg N/fed | 262.4 | 296.2 | 279.3 | 140.9 | 141.6 | 141.2 | 4.983 | 5.136 | 5.060 |
| 120 Kg N/fed | 257.3 | 310.7 | 284.0 | 134.3 | 145.5 | 139.9 | 5.117 | 5.278 | 5.197 |
| 160 Kg N/fed | 259.4 | 298.3 | 278.9 | 133.9 | 138.7 | 136.3 | 4.839 | 5.092 | 4.965 |
| L. S. D. (5%) | 7.260 | 2.870 | - | - | 5.580 | - | 0.148 | 0.080 | 0.082 |
| C. V. % | 5.170 | 7.090 | 6.330 | 10.280 | 8.610 | 9.470 | 5.360 | 4.690 | 5.020 |

**Table (2): Continued.**

| Characters | Ear length (cm) | | | Number of rows / ear | | | Number of kernels / row | | |
|---|---|---|---|---|---|---|---|---|---|
| Treatments | 2001 | 2002 | Comb. | 2001 | 2002 | Comb. | 2001 | 2002 | Comb. |
| Hybrids(H): | | | | | | | | | |
| 1-Single cross 10 | 18.60 | 20.45 | 19.52 | 12.70 | 13.12 | 12.91 | 42.77 | 46.80 | 44.78 |
| 2- Single cross 129 | 17.68 | 20.24 | 18.96 | 14.08 | 14.74 | 14.41 | 39.81 | 44.11 | 41.96 |
| 3- Three way cross 325 | 18.70 | 19.83 | 19.27 | 12.96 | 13.30 | 13.13 | 40.69 | 45.20 | 42.94 |
| 4- Three way cross 352 | 16.56 | 17.57 | 17.07 | 16.03 | 14.91 | 15.47 | 37.13 | 39.18 | 38.16 |
| L. S. D. (5%) | 0.438 | 0.403 | 0.296 | 0.609 | 0.648 | 0.442 | 1.208 | 1.293 | 1.096 |
| Plant density (D): | | | | | | | | | |
| 1- 30000 plant/fed | 17.21 | 18.86 | 18.03 | 13.75 | 14.27 | 14.01 | 38.61 | 42.48 | 40.54 |
| 2- 24000 plant/fed | 18.60 | 20.13 | 19.36 | 14.21 | 13.79 | 14.00 | 41.56 | 44.78 | 43.17 |
| 3- 20000 plant/fed | 17.85 | 19.59 | 18.72 | 13.87 | 14.00 | 13.93 | 40.13 | 44.21 | 42.17 |
| L. S. D. (5%) | 0.399 | 0.667 | 0.323 | - | - | - | 0.757 | 1.830 | 0.823 |
| Nitrogen levels (N) | | | | | | | | | |
| 0 Kg N/fed | 14.85 | 17.65 | 16.25 | 13.33 | 13.72 | 13.53 | 31.92 | 39.76 | 35.84 |
| 40 Kg N/fed | 16.64 | 19.15 | 17.90 | 13.75 | 13.97 | 13.86 | 37.44 | 43.64 | 40.54 |
| 80 Kg N/fed | 19.09 | 20.24 | 19.66 | 14.08 | 14.03 | 14.06 | 43.59 | 45.63 | 44.61 |
| 120 Kg N/fed | 20.56 | 20.91 | 20.74 | 14.56 | 14.19 | 14.38 | 46.13 | 46.40 | 46.26 |
| 160 Kg N/fed | 18.29 | 19.66 | 18.98 | 13.99 | 14.18 | 14.08 | 41.42 | 43.68 | 42.55 |
| L. S. D. (5%) | 0.662 | 0.582 | 0.430 | 0.792 | - | 0.496 | 1.484 | 1.687 | 0.880 |
| C. V. % | 5.850 | 4.940 | 5.380 | 10.430 | 11.040 | 10.740 | 7.200 | 7.050 | 7.130 |

## Table (2): Continued.

| Characters | 100 – Kernel weight(gm) | | | Shelling % | | | Grain yield / plant (gm) | | | Grain yield (ard. / fed) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Treatments | 2001 | 2002 | Comb. | 2001 | 2002 | Comb. | 2001 | 2002 | Comb. | 2001 | 2002 | Comb. |
| Hybrids (H): | | | | | | | | | | | | |
| 1- Single cross 10 | 35.17 | 41.94 | 38.56 | 84.87 | 86.73 | 85.80 | 225.9 | 279.1 | 252.5 | 21.50 | 26.13 | 23.81 |
| 2- Single cross 129 | 30.53 | 36.77 | 33.65 | 85.69 | 86.35 | 86.02 | 198.1 | 250.2 | 224.1 | 22.39 | 22.70 | 22.54 |
| 3- Three way cross 325 | 35.44 | 41.44 | 38.44 | 84.86 | 86.53 | 85.64 | 214.7 | 268.8 | 241.8 | 21.30 | 22.58 | 22.05 |
| 4- Three way cross 352 | 30.53 | 36.74 | 33.64 | 83.41 | 85.46 | 84.44 | 207.8 | 229.6 | 218.7 | 22.25 | 21.85 | 21.94 |
| L. S. D. (5%) | 1.341 | 1.532 | 1.013 | 0.972 | 0.599 | 0.568 | 3.640 | 3.326 | 2.451 | 0.354 | 0.391 | 0.263 |
| Plant density (D): | | | | | | | | | | | | |
| 1- 30000 plant/fed | 31.88 | 37.66 | 34.77 | 84.44 | 86.13 | 85.29 | 195.5 | 245.2 | 220.3 | 20.18 | 21.87 | 21.03 |
| 2- 24000 plant/fed | 34.23 | 40.54 | 37.38 | 84.55 | 86.46 | 85.50 | 227.6 | 268.8 | 248.2 | 23.75 | 25.02 | 24.38 |
| 3- 20000 plant/fed | 32.65 | 39.48 | 36.06 | 85.05 | 86.22 | 85.64 | 211.7 | 256.8 | 234.3 | 21.65 | 23.05 | 22.35 |
| L. S. D. (5%) | 0.947 | 1.565 | 0.760 | - | - | - | 5.590 | 1.713 | 2.429 | 0.478 | 0.494 | 0.285 |
| Nitrogen levels (N) | | | | | | | | | | | | |
| 0 Kg N/fed | 27.14 | 35.75 | 31.44 | 83.09 | 86.44 | 84.77 | 131.5 | 204.9 | 168.2 | 12.98 | 14.31 | 13.65 |
| 40 Kg N/fed | 31.08 | 37.03 | 34.06 | 84.72 | 86.06 | 85.39 | 181.5 | 238.1 | 209.8 | 17.32 | 19.37 | 18.35 |
| 80 Kg N/fed | 34.96 | 40.36 | 37.66 | 85.34 | 86.10 | 85.72 | 244.7 | 277.4 | 261.1 | 25.91 | 26.58 | 26.24 |
| 120 Kg N/fed | 37.22 | 43.32 | 40.27 | 85.32 | 86.55 | 85.93 | 281.3 | 305.3 | 293.3 | 31.53 | 32.66 | 32.09 |
| 160 Kg N/fed | 34.19 | 39.67 | 36.93 | 84.94 | 86.20 | 85.57 | 219.1 | 258.9 | 239.0 | 21.55 | 23.65 | 22.60 |
| L. S. D (5%) | 1.624 | 1.231 | 0.994 | 1.401 | - | 0.767 | 3.620 | 2.917 | 2.267 | 0.484 | 0.416 | 0.311 |
| C. V. % | 9.730 | 9.330 | 9.540 | 2.740 | 1.660 | 2.260 | 4.110 | 3.090 | 3.550 | 3.880 | 4.000 | 3.950 |

values compared to both 20000 and 30000 plants / fed. Grain yield / fed and all yield component characters of maize *i. e.* ear diameter, ear length, the number of rows / ear, the number of kernels / row, 100 – kernel weight and grain yield / plant decreased as a result of increasing population density to 30000 plant / fed. This result is mainly due to the fact that plants grown at higher densities are less vigorous than plants in low density, and this might be responsible mainly for the reduction in ear characters and ear weight. These results are similar to those obtained by El-Deeb (1990), Matta *et al.* (1990), Badr *et al.* (1993), Shams El-Din and El-Habbak (1996) and El-Douby *et al.* (2001).

### 3.3. Effect of nitrogen levels

The results in Table (2) indicate that increasing nitrogen level significantly increased grain yield / fed as well as different yield attributes of maize except plant and ear height and shelling % (in the second season) registered a significant increase to applied N up to 120 kg / fed. These results show that adding 120 kg / fed of N increased photosynthetic area of maize without harmful shading effect. In addition, the increase in maize grain yield due to the increase in nitrogen level is a result of the effect of N fertilizer in increasing yield components. The application of 40, 80, 120 and 160 kg N / fed increased grain yield over zero (control treatment) by 34.43%, 92.23%, 135.09% and 65.57%, respectively, in combined analysis. These results are substantiated with the studies conducted by Salwau (1993), Moshtohory *et al.* (1995), El-Gezawy (1996), Shams El-Din and El-Habbak (1996), El-Douby *et al.* (2001), Mohamed *et al.* (2002) and Carlos Costa *et al.* (2002).

### 3.4. Interaction effects

The data in Table (3) indicate that ear diameter, ear length, the number of kernels / row, 100 – kernel weight, grain yield / plant and grain yield (ard /fed) were significantly affected by the interactions between plant density and nitrogen fertilizer level. The highest values ($D_2$ X $N_4$) were obtained with planting 24000 plant / fed and applying 120 kg N / fed. The summary of the ffects of the interaction between N – fertilizers and hybrids on grain yield per plant and feddan indicated that the addition of 120 kg N / fed to maize was enough to - maximize grain yield. The highest values of grain yield per plant and feddan being 318.682 gm and 33.31 ard / fed, respectively, were achieved with single cross 10 and 120 kg N / fed ( $N_4$ X $H_1$ ). Other tested hybrids had no significant interaction with nitrogen level. These results are in agreement with those obtained by Ashmawy (1995), El – Douby *et al.*, (2001) and Mohamed *et al.*, (2002).

**Table (3): Significance, highest value and combination of the interaction effects on some maize characters in combined analysis.**

| Characters | D X N | Highest value | N X H | Highest value |
|---|---|---|---|---|
| Ear diameter (cm) | $D_2$ X $N_4$ | 5.304 | —— | —— |
| Ear length (cm) | $D_2$ X $N_4$ | 21.196 | —— | —— |
| Number of kernels / row | $D_2$ X $N_4$ | 46.979 | —— | —— |
| 100 – kernel weight gm | $D_2$ X $N_4$ | 42.125 | —— | —— |
| Grain yield / plant, gm | $D_2$ X $N_4$ | 312.268 | $N_4$ X $H_1$ | 318.682 |
| Grain yield (ard / fed) | $D_2$ X $N_4$ | 35.478 | $N_4$ X $H_1$ | 33.310 |

$D_1$ : 30000 plant / fed
$D_2$ : 24000 plant / fed
$D_3$ : 20000 plant / fed

$N_1$ : Zero Kg N / fed
$N_2$ : 40 Kg N / fed
$N_3$ : 80 Kg N / fed
$N_4$: 120 Kg N / fed
$N_5$ : 160 Kg N / fed

$H_1$ : Single cross 10
$H_2$ : Single cross 129
$H_3$ : Three way cross 325
$H_4$ : Three way cross 352

### 3.5. Simple correlation

Simple correlation coefficients between grain yield / plant and its components over two seasons are presented in Table (4). The results indicate positive and highly significant correlation coefficients between grain yield / plant and its components except the number of rows / ear. The results showed that these characters have the most prominent effects on grain yield, their total contribution to the variation in grain yield / plant was 92 %. Also, it appears from Table 4 that all characters were highly significantly and positively associated except for ear height and each of ear diameter, ear length, the number of rows / ear, the number of kernels / row and shelling %. Also, there was a negative and highly significant association between the number of rows / ear and each of ear length, the number of kernels / row, 100 – kernel weight and shelling %, In addition, there was a negative and significant correlation coefficient between plant height

**Table (4): Simple correlation coefficients between grain yield / plant and its components over both seasons.**

| Characters | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| 1- Plant height | - | | | | | | | |
| 2- Ear height | 0.454** | - | | | | | | |
| 3- Ear diameter | 0.192** | 0.073 | - | | | | | |
| 4- Ear length | 0.333** | 0.102 | 0.466** | - | | | | |
| 5- No. of rows/ear | -0.113* | -0.049 | 0.422** | -0.19** | - | | | |
| 6- No. of kernels/row | 0.246** | 0.098 | 0.419** | 0.896** | -0.233** | - | | |
| 7- 100-Kernel weight | 0.451** | 0.172** | 0.492** | 0.69** | -0.33** | 0.635** | - | |
| 8- Shelling % | 0.225** | 0.068 | 0.132** | 0.32** | -0.183** | 0.375** | 0.351** | - |
| 9- Grain yield / plant | 0.327** | 0.154** | 0.701** | 0.851** | 0.049 | 0.818** | 0.777** | 0.356** |

*,** indicate 0.05 and 0.01 levels of significance, respectively.

- Coefficient of determination (R – Square) = 0.917
- Standard error of estimate = 15.757

and the number of rows / ear. Consequently, these results indicate that selection practiced for the improvement of any of a set of positively correlated characters, would automatically improve the other, even though direct selection for its improvement has not been made. These results are in agreement with those obtained by Hassib (1997), Mohamed *et al* (2002).

### 3.6. Principal component analysis

Principal component analysis results over two seasons of 2001 and 2002 are given in Table (5). The results show that the two independent components were considered for the two seasons. The first component accounted for 77.037% of the total variation. This component included ear diameter, ear length, the number of kernels / row, 100 – kernel weight, shelling% and grain yield / plant. The second component accounted for 18.037% of the total variation. This component was represented by plant height, ear height and the number of rows / ear.

**Table (5): Principal component analysis over both seasons of 2001 and 2002.**

| Characters | Component | |
|---|---|---|
| | 1 | 2 |
| 1- Plant height cm | 0.225 | 0.939 |
| 2- Ear height cm | 0.052 | 0.252 |
| 3- Ear diameter | 0.005 | -0.002 |
| 4- Ear length | 0.037 | -0.004 |
| 5- Number of rows / ear | 0.001 | -0.009 |
| 6- Number of kernels / row | 0.088 | -0.027 |
| 7- 100 – Kernel weight | 0.087 | 0.025 |
| 8- Shelling % | 0.015 | 0.006 |
| 9- Grain yield / plant | 0.964 | -0.232 |
| Percentage variance | 77.037 | 18.606 |
| Cumulative variance % | 77.037 | 95.643 |

### 3.7. Response curve analysis:

Two response models namely: linear and quadratic were applied to the data of grain yield ard./fed response to N for each of the four tested maize hyprids under each of the three plant densities combined over the two season. Coefficient of determination ($R^2$), standard error

**Table (6): Coefficient of determination ($R^2$), standard error of estimate (SE) and calculated F value for linear and quadratic models for grain yield of maize hybrids under three plant densities over both seasons .**

| Hybrids | S. C. 10 | | | S. C. 129 | | | T. W. C. 325 | | | T. W. C. 352 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $R^2$% | SE | F(cal.) | $R^2$% | SE | F(cal.) | R% | SE | F(cal.) | $R^2$% | SE | F(cal.) |
| 30000 Plant/fed | | | | | | | | | | | | |
| Linear | 45.9 | 5.11 | 23.8** | 52.5 | 4.18 | 30.9** | 50.9 | 4.65 | 29.0** | 49.1 | 4.28 | 27.0** |
| Quadratic | 70.9 | 3.82 | 32.9** | 78.3 | 2.20 | 92.5** | 82.0 | 2.86 | 61.7** | 86.3 | 2.26 | 85.2** |
| 24000 Plant/fed | | | | | | | | | | | | |
| Linear | 44.1 | 5.79 | 22.1** | 44.5 | 5.32 | 22.4** | 41.6 | 5.66 | 20.0** | 40.1 | 5.40 | 18.7** |
| Quadratic | 69.1 | 4.39 | 30.2** | 76.0 | 3.56 | 42.6** | 70.3 | 4.11 | 32.0** | 71.0 | 3.90 | 33.1** |
| 20000 Plant/fed | | | | | | | | | | | | |
| Linear | 45.1 | 5.21 | 23.0** | 52.8 | 4.64 | 31.3** | 46.7 | 4.73 | 24.5** | 45.2 | 4.51 | 23.1** |
| Quadratic | 73.4 | 3.70 | 37.2** | 82.8 | 2.90 | 62.5** | 79.3 | 3.00 | 51.6** | 81.0 | 2.71 | 57.6** |

of estimate (SE) and calculated F value for each of the linear and quadratic models for grain yield of maize hybrids are presented in Table (6). Regression equations, maximum N dose and yield at maximum N dose are displayed in Table (7). Graphic illustrations are shown in Figures (1 – 3).

Examining Table (6), it could be noticed that the best model fitted to the yield data of all hybrids was quadratic. It had coefficient of determination ($R^2$) greater than those of the linear model for the four tested hybrids under the three plant densities. Moreover, values of standard error of estimate (SE) of quadratic equation were smaller than those of the linear equation. Therefore, the quadratic model worked well for describing the relation between grain yield of maize hybrids and nitrogen fertilization under the three densities, (Table 6 and Figures 1 – 3). These results are in agreement with those obtained by Balko and Russell (1980), Fox and Piekielek (1983), Cerrato and Blackmer (1990), Oberle and Keeney (1990), Ashmawy (1995), Stecker *et al.*, (1995), El – Douby *et al.* (2001) and Carlos Costa *et al.*, (2002).

**Table (7): Regression equation, maximum nitrogen dose and grain yield at maximum nitrogen dose under three plant densities for maize hybrids over seasons .**

| Hybrids | Regression equation | Maximum N dose (Kg / fed) | Yield at maximum N dose (ard / fed) |
|---|---|---|---|
| 30000 Plants/fed.: | | | |
| Single cross 10 | $Y=11.292+0.281X-0.0012X^2$ | 112 | 30.22 |
| Single cross 129 | $Y=10.723+0.281X-0.0012X^2$ | 109 | 29.47 |
| Three way cross 325 | $Y=9.706+0.295X-0.0013X^2$ | 110 | 26.43 |
| Three way cross 352 | $Y=10.488+0.283X-0.0013X^2$ | 107 | 25.89 |
| 24000 Plants/fed.: | | | |
| Single cross 10 | $Y=14.214+0.312X-0.0014X^2$ | 111 | 31.60 |
| Single cross 129 | $Y=13.131+0.312X-0.0014X^2$ | 108 | 30.50 |
| Three way cross 325 | $Y=12.442+0.301X-0.0014X^2$ | 111 | 29.71 |
| Three way cross 352 | $Y=13.419+0.302X-0.0014X^2$ | 107 | 29.70 |
| 20000 Plants/fed.: | | | |
| Single cross 10 | $Y=12.836+0.297X-0.0013X^2$ | 110 | 29.78 |
| Single cross 129 | $Y=11.851+0.295X-0.0013X^2$ | 112 | 28.58 |
| Three way cross 325 | $Y=11.281+0.289X-0.0013X^2$ | 108 | 27.33 |
| Three way cross 352 | $Y=11.872+0.281X-0.0013X^2$ | 107 | 27.06 |

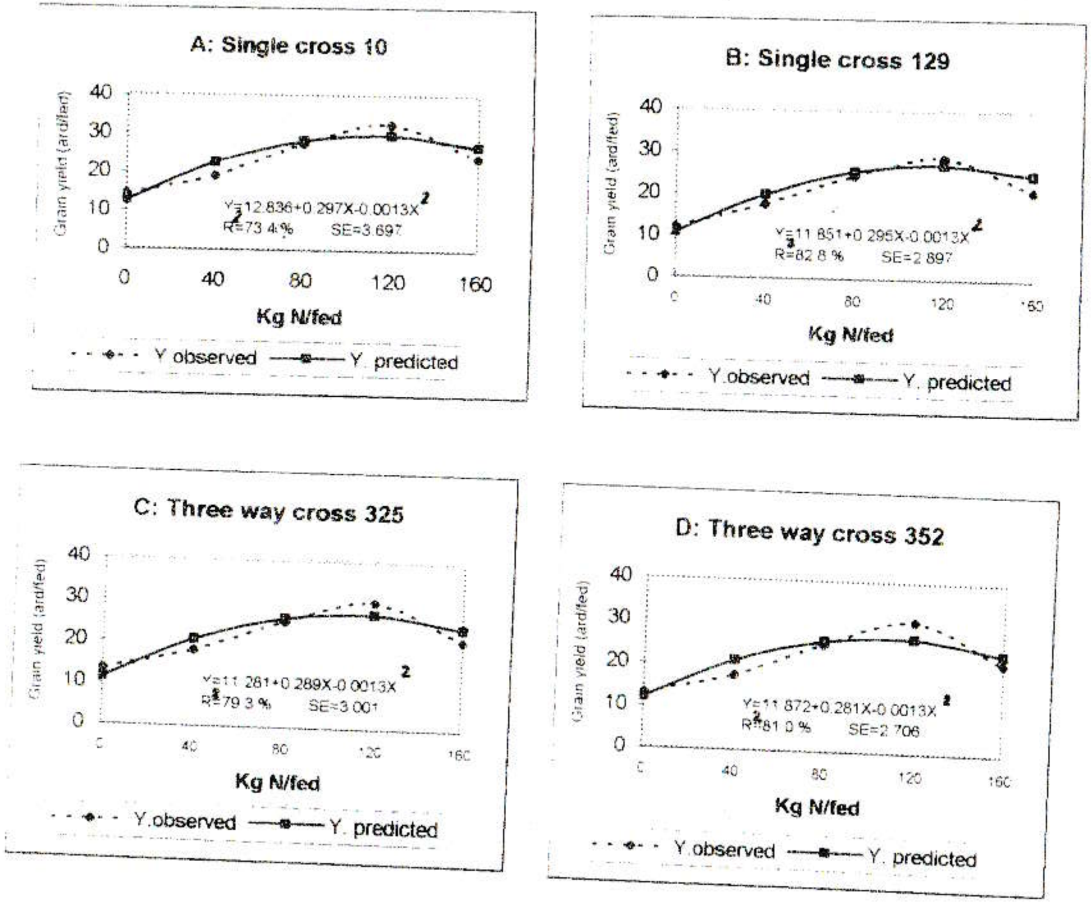


**Fig.(1): Response of grain yield of maize hybrids to N levels at 20000 plant/fed.**

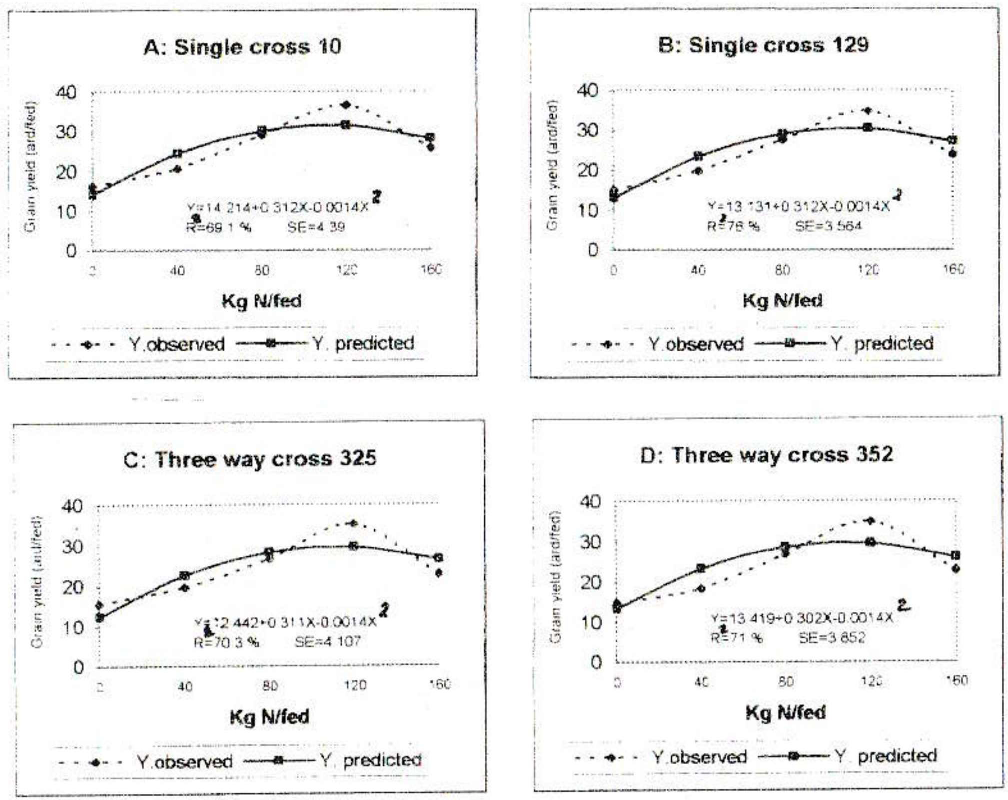


Fig.(2): Response of grain yield of maize hybrids to N levels at 24000 plant/fed.

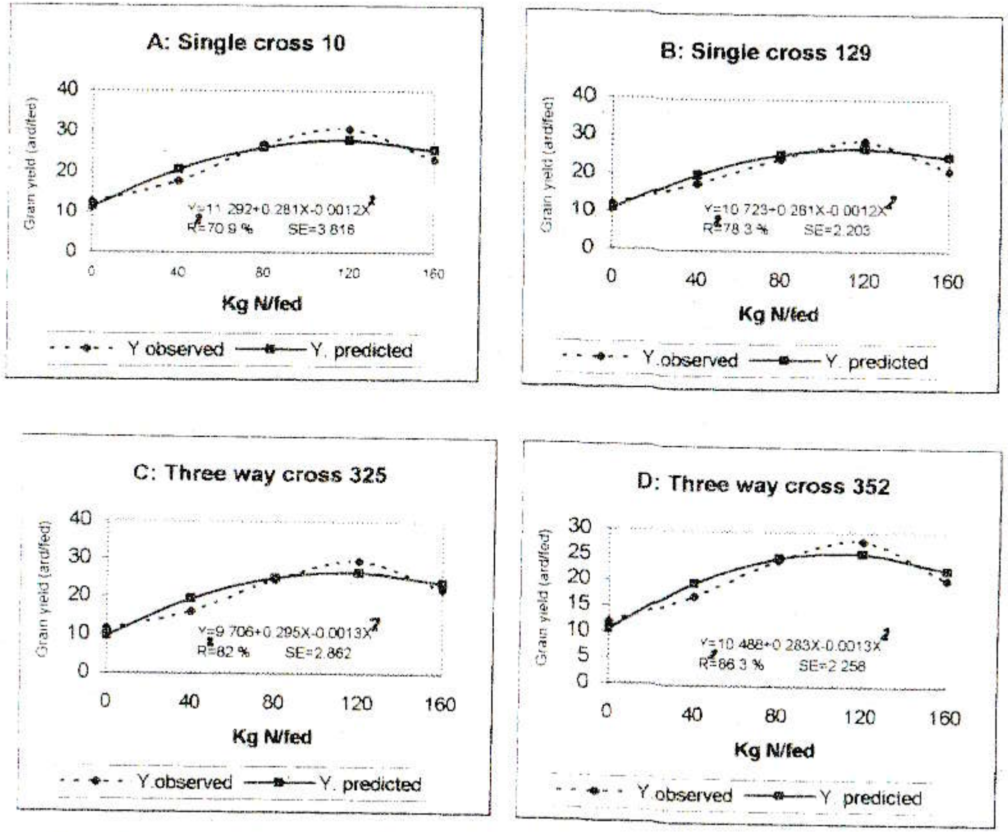


**Fig.(3): Response of grain yield of maize hybrids to N levels at 30000 plant/fed.**

The results in Table (7) also show that the maximum N level ranged from 107 kg N / fed for three way cross 352 to 112 kg N / fed for single cross 10 and single cross 129 under the three plant densities. Grain yield at the maximum N dose ranged from 25.89 ard /fed for three way cross 352 under 30000 plants / fed to 31.6 ard / fed for single cross 10 under 24000 plants / fed. These results are in line with those reported by Carlos Costa *et al.*, (2002) and Mohamed *et al.*, (2002).

**3.8. Economic analysis**

The economic analysis results of nitrogen fertilization are shown in Table (8). In the first density (30000 plants / fed), the optimum nitrogen rate ranged from 103.5 kg N / fed to 111.3 kg N / fed. Grain yield at the optimum dose of N ranged from 25.8 ard / fed to 27.7 ard / fed. However, the net profit ranged from 2686.3 to 2877.8 £E / fed. In the second density (24000 plants / fed),the optimum N rate ranged from 102.9 kg N/ fed.to 106.5 kg N/fed.Grain

**Table (8): The economic analysis of nitrogen fertilization of maize hybrids during three plant densities over seasons .**

| Hybrids | Optimum N dose (Kg/fed) | Yield at optimum N ( ard / fed.) | Net return (£E / fed.) |
|---|---|---|---|
| 30000 Plants / fed.: | | | |
| Single cross 10 | 111.318 | 27.702 | 2877.79 |
| Single cross 129 | 111.318 | 27.133 | 2815.20 |
| Three way cross 325 | 108.140 | 26.405 | 2739.96 |
| Three way cross 352 | 103.525 | 25.853 | 2686.27 |
| 24000 Plants / fed.: | | | |
| Single cross 10 | 106.487 | 31.350 | 3286.43 |
| Single cross 129 | 106.487 | 30.480 | 3190.73 |
| Three way cross 325 | 106.130 | 29.679 | 3103.16 |
| Three way cross 352 | 102.916 | 29.671 | 3107.17 |
| 20000 Plants / fed.: | | | |
| Single cross 10 | 108.909 | 29.762 | 3108.06 |
| Single cross 129 | 108.140 | 28.550 | 2975.91 |
| Three way cross 325 | 105.832 | 27.306 | 2842.58 |
| Three way cross 352 | 102.755 | 27.020 | 2815.81 |

yield of maize at the optimum N dose ranged from 29.7 to 31.4 ard / fed. Return ranged from 3103.2 to 3286.4 £E / fed. In the third density (20000 plants / fed), the optimum N rate ranged from 102.8 kg N / fed to 108.9 kg N / fed. Grain yield of maize at the optimum N dose ranged from 27 ard / fed to 29.8 ard / fed. Net return ranged from 2815.8 to 3108.1 £E / fed.

From the previous results, planting maize at the optimum N rate and the economic optimum nitrogen rate ranged from 103 – 111 kg N / fed for the tested hybrids. These findings are in harmony with those obtained by Carlos Costa *et al*., (2002) and Mohamed *et al*., (2002).

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## تحليل المكون ومنحنيات استجابة بعض هجن الذرة الشامية لمستويات مختلفة من التسميد الازوتى والكثافة النباتية

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مركز البحوث الزراعية – الجيزة

### ملخص

اقيمت تجربتان حقليتان بمحطة البحوث الزراعية بالجميزة خلال الموسمين الزراعيين الصيفيين ٢٠٠١ و٢٠٠٢ لدراسة علاقة الارتباط بين المحصول ومكوناته والتعرف على القدرة الانتاجية لأربعة هجن من الذره الشامية (هجين فردى ١٠, هجين فردى ١٢٩, هجين ثلاثى ٣٢٥ , هجين ثلاثى ٣٥٢) واستجابتها لمستويات التسميد الأزوتي ( صفر , ٤٠, ٨٠, ١٢٠, ١٦٠ كجم أزوت / فدان) تحت كثافات نباتية (٢٠, ٢٤, ٣٠ ألف نبات / فدان). واستخدم تصميم القطع المنشقة مرتين واجريت التحليلات الإحصائية التالية: تحليل التباين والارتباط البسيط وتحليل المكون. كما استخدم اسلوب تحليل المنحنيات لتحديد

درجة استجابة المحصول للسماد الأزوتى مع إجراء تحليل اقتصادي لتقدير أنسب معدل للسماد الأزوتى مع تقدير العائد بالجنيه نتيجة إضافة المعدل الأنسب من الأزوت. ويمكن تلخيص أهم النتائج فيما يلى:

١- تفوق هجين فردى ١٠ معنويا على الهجن الثلاثة الاخرى (هجين فردى ١٢٩, هجين ثلاثى ٣٢٥, هجين ثلاثى ٣٥٢) فى كل من ارتفاع أول كوز، طول الكوز, عدد حبوب الصف , وزن ١٠٠ حبة ومحصول النبات من الحبوب وكذلك محصول الفدان من الحبوب. بينما كانت نباتات هجين ثلاثى ٣٢٥ هى الأطول معنويا بين كل الهجن فى حين كانت كيزان الهجين الثلاثى ٣٥٢ الأكبر فى قطر الكوز والأكثر فى عدد الصفوف.

٢- أدت زراعة نباتات الذرة على مسافة ٢٥ سم بين النباتات (٢٤ ألف نبات / فدان) إلى زيادة معنوية في كل الصفات تحت الدراسة مثل: قطر الكوز – طول الكوز – عدد حبوب الصف – وزن ١٠٠ حبة ومحصول كل من النبات والفدان من الحبوب. بينما لم تتأثر صفات ارتفاع النبات وارتفاع أول كوز وعدد صفوف الكوز والنسبة المئوية لمعدل التفريط. بينما أدى زيادة الكثافة إلى ٣٠ ألف نبات للفدان إلى نقص محصول الفدان من الحبوب لأقل مستوى.

٣- أدت زيادة التسميد الازوتى حتى ١٢٠ كجم أزوت / فدان لزيادة محصول الحبوب بنسبة ١٣٥,٠٩% مقارنة بمعاملة عدم التسميد (صفر) ووصل إنتاج الفدان من الحبوب إلى ٣٢,٠٩ أردب. كذلك كانت هناك زيادة معنوية فى جميع مكونات المحصول ماعدا ارتفاع النبات وارتفاع أول كوز والنسبة المئوية لمعدل التفريط ( في الموسم الثاني).

٤- تأثرت صفات قطر وطول الكوز – عدد حبوب الصف – وزن ١٠٠ حبة ومحصول الحبوب لكل من النبات والفدان معنويا بالتفاعل بين الكثافة النباتية والتسميد الازوتى وتأثر محصول الحبوب لكل من النبات والفدان معنويا بالتفاعل بين الهجن والتسميد الازوتى بينما لم تتأثر باقي الصفات كما أظهرت النتائج عدم وجود تاثيرات معنوية لكل من التفاعل بين الهجنX الكثافة النباتية والتفاعل الثلاثى بين الهجن X الكثافة النباتية X التسميد على الصفات المدروسة.

وعموما يمكن القول بأن زراعة الهجين الفردي ١٠ بمعدل ٢٤ ألف نبات / فدان وتسميده بمعدل ١٢٠ كجم أزوت للفدان تعطى أعلى محصول من حبوب الذرة.

٥- أوضحت النتائج وجود ارتباط موجب عالى المعنوية بين محصـــول حبـــوب النبات وجميع الصفات المدروسة ماعدا عدد صفوف الكوز.

٦- باستخدام تحليل المكون (principal component analysis) فصلت الصفـات المدروسة لمكونين الأول يضم صفات قطر وطول الكوزوعدد حبوب الصف ووزن ١٠٠ حبة والنسبه المئوية لمعدل التفريط ومحصـــول النبـــات مـــن الحبوب أما المكون الثانى فاشتمل على طول النبات وارتفاع أول كوز وعدد صفوف الكوز.

٧- أظهر تحليل المنحنيات أن استجابة محصول حبوب الذرة للتسميد الأزوتـــى تتبع معادلة الدرجه الثانية حيث كانت معنوية وأعطت أعلى قيمـــة لمعـــامل التحديد ($R^2$) وأقل قيمه للخطأ القياسى (SE) مقارنة بالدرجه الأولى.

كما أظهرت النتائج استجابة محصول الحبوب لزيادة التسميد الأزوتى وتكون الزيادة فى المحصول معنوية وموجبة . يتضح من نتائج التحليل الاقتصـــادى أن أنسب معدل للتسميد الأزوتى يتراوح بين ١٠٣ إلـــى ١١١ كجـــم أزوت للفـــدان وتراوح محصول الحبوب عند أنسب معدل للتسميد الأزوتى بيـــن ٢٦ إلـــى ٣١ أردب / فدان محققا عائدا اقتصاديا يتراوح من ٢٦٨٦ إلى ٣٢٨٦ جنيها للفدان.

المجلة العلمية لكلية الزراعة – جامعة القاهرة – المجلد (٥٥) العدد الرابـــــع (أكتوبر ٢٠٠٤):٥٣١-٥٥٦.