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Multivariate Analysis For Yield and Its Components In Maize Under Zinc and Nitrogen Fertilization Levels

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Abstract: The study was carried out at the Agricultural Research and Experimental Center of the Faculty of Agriculture, Moshtohor. Five statistical procedures of relating yield components to yield, i.e., simple correlation, path coefficient analysis, stepwise regression, multiple regressions and factor analysis were applied to yield contributing characters to determine their functional relationships to yield and determine the effect of foliar application of zinc sulphate (zero, 0.2 and 0.4%) and six nitrogen fertilizer levels (60, 80, 100, 120, 140 and 160 kg/fed) on growth, yield and yield components in maize. The obtained results were as follows: Highly significant positive correlation values were detected between grain yield/plant and each of ear height, ear diameter, ear length, number of kernels/row, number of rows/ear and 100-kernel weight. Kernel ear weight had the most direct effect on grain yield/plant followed by direct effect of ear diameter, ear height and ear length. In Multiple linear regressions, the relative contribution for all yield factors explained 88.3% of the total variation in grain yield. The stepwise regression show that, kernel ear weight, ear height, ear length, ear diameter and 100-kernel weight were the most contributing variables in grain yield of maize (88.2% in grain yield variation). The factor analysis grouped the studied variables into two factors, which explained 90.57% of the total variability in the dependence structure. The first factor contributed 49.16% while, the second factor was responsible for 41.4% of the total variability. Zinc application as spray resulted in significant increases in plant height, stem diameter, ear length, ear diameter, No. of kernels/row, ear weight, kernels ear weight, 100-kernel weight, grain yield/plant and grain yield/fed in both seasons, ear height and No. of ears/plant in the second season. Applying of 140 or 160 kg N/fed increased significantly all growth characters, yield and yield components in the first and second seasons. The interaction between spraying of zinc and N fertilizer levels had significant effect on plant height, ear height, ear length, ear diameter, No. of kernels/row and grain yield/fed in the first and second seasons, stem diameter in the first season and No. of rows/ear, kernels ear weight and grain yield/plant in the second one. The highest values obtained for grain yield plant and fed were detected by spraying with zinc at (0.4% Zn So_4) and applied 140 N/fed.

Key words: Multivariate, Foliar application of zinc, N-levels, Growth, Yield and yield components of maize.

INTRODUCTION

Yield of maize is the integrated effect of many variables that effect plant growth during the season. Growth analysis and relative contribution studies may help in interpreting the results and perhaps lead the breeders to obtain better selection criteria for yield. They have realized that direct selection of yield on individual plant basis is rather ineffective. Several statistical techniques, such as correlation, path coefficient analysis, multivariate regression analysis, factor analysis and stepwise regression analysis are very beneficial in explaining the relationship between yield and contributing factors.

Mohamed and Sedhom (1993) concluded that grain yield/plant of corn was highly positively correlated with ear length, number of grains/row and 100-kernel weight but positively and significantly correlated with both of plant height and ear diameter. Several studies have been conducted using path coefficient to determine the direct and indirect effects as well as the relative contribution of maize characters contributing to grain yield/plant (Mohamed and Sedhom, 1993; Salama, *et al.,* 1994; Soliman, *et al.,* 1999; Atia, *et al.,* 2001; Ashmawy, 2003; El-Badawy, 2006 and Ahmed *et al.,* 2009).

(Shafshak *et al.,* 1989; Ashmawy and Mohamed 1998; Ashmawy 2003; and Ahmed *et al* 2009) in comparison between the full model regression and the stepwise regression procedure concluded that the coefficient of determination for full model regression and partial correlation was more efficient than stepwise regression. (El-Kalla and El-Rayes 1984; Atia *et al.,* 2001) used factor analysis in maize and sorghum to determine the dependence relationship between yield and yield components. El-Badawy (2006) found that using factor analysis by plant breeders has the potential of increasing the comprehension of causal relationships of variables and can help to determine the nature and sequence of traits to be selected in breeding programs. Also, path coefficient analysis is used to determine the direct and indirect effect, while stepwise is used to determine the best prediction equation for yield.

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Meantime zinc and nitrogen fertilization greatly affect yield and its components. As for zinc spraying, Khalil (1992) found that growth characters significantly increased by increasing Zn level up to 0.8%. Hefni *et al.* (1993 a, b) illustrated that the mean values of leaf area/plant and leaf area index at 60 and 75 day after sowing and stem diameter significantly increased by increasing the level of zinc sulphate up to 0.3%. Ashoub *et al.* (1996) reported that zinc application as foliar spray resulted in significant increases in ear length, ear diameter, number of grains/row, weight of 100 grains, shelling percentage, grain and straw yield / fed in the two seasons. Mehasen and Saeed (2006) found that zinc application as spray resulted in significant increases in plant height, ear height, number of ears/plant, ear length, weight of kernels/ear, grain yield per plant and fed in the combined analysis.

With regard to growth characters, grain yield and yield components were positively affected by increasing the rate of nitrogen fertilizer (Zaghloul, 1999; Salem, 1999; El-Banna and Gomaa, 2000; Sobh *et al.,* 2000; El-Banna, 2001, El-Wakil, 2002 and Mehasen and Saeed 2006).

This study aimed to: 1- Determine the correlation between maize yield and yield components. 2- Determine the most important variables and their relative contribution to maize yield variability. 3- Investigate the effect of N and zinc fertilizers on growth, yield and yield components to determine the degree of its response to N and zinc fertilizers.

MATERIALS AND METHODS

Two field experiments were conducted at the Experimental Research Center, Faculty of Agriculture at Moshtohor, during the two summer successive growing seasons of 2009 and 2010 to find out the effect of N fertilization level (60, 80, 100, 120, 140 and 160 Kg N / fed.) and three foliar applications of zinc (without zinc, 0.2 and 0.4% $ZnSO_4$) on maize cultivar (Giza 2). The treatments were assigned in a split-plot design with three replications. Three foliar applications of zinc were arranged at random in the main plots while levels of N – fertilizer occupied the sub– plots.

The soil type was clay with pH value of 7.89 and 7.80. Organic mater was 1.85 and 1.96%. Total N was 0.19 and 0.21% and contained 0.78 and 0.88 ppm of zinc in the first and second growing seasons, respectively. The experimental sites were preceded by wheat in the two seasons. Each experiment included 18 treatments which were the combinations of three foliar application of zinc (without zinc, 0.2 and 0.4% $ZnSO_4$) and six nitrogen levels (60, 80, 100, 120,140 and 160 kg N/fed) in the form of ammonium nitrate 33.5%N. Nitrogen levels were applied in two split applications before the first and second irrigations. Foliar application of zinc equal to 400 liters solution / fed spraying at 45 days from planting.

Planting has been done at 28th and 30th on May 2009 and 2010, respectively. Each plot was 3x3.5 m and consisted of five rows 70 cm apart. Intra-hill spacing was 25 cm. Hills were thinned to one plant/hill after 21 days from planting. Recommended cultural practices for ordinary maize fields in the area were followed during growing seasons. Random sample of 10 guarded plants in each plot were taken to evaluate plant height (cm), ear height (cm), stem diameter (cm), No. of ears/plant, ear length (cm), ear diameter (cm), No. of rows/ear, No. of kernels/row, ear weight (g), kernels ear weight (g), 100-kernel weight and grain yield/plant. Grain yield (kg/fed) was recorded on whole plot basis and adjusted to 15.5% grain moisture content.

Analysis of variance was done for the data of each season separately and combined analysis was performed for the data over the two seasons according to Snedecor and Cochran (1981) treatment means were compared using least significant difference test at 0.05 level of significance. The following estimates were calculated:
Simple and multiple correlation and coefficient of determination were computed between the above mentioned characters as outlined by Steel and Torrie (1987).

Path coefficient analysis was used as applied by Dewey and Lu (1959) and Duarte and Adams (1972).

Stepwise linear regression, (Draper and Smith, 1966), to determine the appropriate variables responsible for most variation in yield. The relative contribution was calculated as (R^2).
The factor analysis by Cattell (1965).

Multiple linear regressions between seed yield and yield components so as to construct a prediction model for yield; coefficient of determination R^2 was estimated to evaluate the relative contribution of yield attributes (Snedecor and Cochran, 1981).

RESULTS AND DISCUSSIONS

Simple Phenotypic Correlation:

The simple correlation coefficients between each two traits were estimated in the combined analysis. The association between grain yield/plant and its related characters in maize plant gives very useful information for the plant breeder who wants to incorporate desirable characters.

Table (1) shows highly significant positive phenotypic correlation values between grain yield/plant and each of other traits in the combined analysis. Therefore, selection for each of higher kernels ear weight followed by ear diameter, ear height, No. of kernels/row, 100-kernel weight and ear length is more effective for obtaining new higher yielding varieties. Highly significant and positive correlation values were detected between 100-kernel weight and each of ear diameter, ear height, No. of kernels/row, ear length and kernels ear weight. Also, there was positive and highly significant association between kernels ear weight and each of ear diameter, ear height, No. of kernels/row and ear length.

Table 1: Simple correlation coefficients among grain yield/plant and its related characters in maize (Combined over both seasons).

Characters	Ear height (X_1)	Ear length (X_2)	Ear diameter (X_3)	No. of kernels /row (X_4)	Kernels ear weight (X_5)	100-kernel weight (X_6)	Grain yield/ plant (X_7)
(X_1)	1.000						
(X_2)	0.789**	1.000					
(X_3)	0.891**	0.839**	1.000				
(X_4)	0.863**	0.809**	0.921**	1.000			
(X_5)	0.878**	0.772**	0.888**	0.857**	1.000		
(X_6)	0.811**	0.768**	0.839**	0.809**	0.761**	1.000	
(X_7)	0.868**	0.708**	0.871**	0.837**	0.926**	0.759**	1.000

** Significant at 1% level of probability.

Significant positive correlation coefficient values were detected between No. of kernels/row and each of ear diameter, ear height and ear length. Also, positive correlation coefficients were detected between ear diameter and each of ear height and ear length. Ear length expressed highly significant and positive correlation with ear height. These results are in agreement with those obtained by Mohamed and Sedhom (1993), Atia *et al* (2001), Ashmawy (2003) and El-Badawy (2006).

Path Coefficient:

Direct, indirect effects, total contribution and percent contribution of each variable to grain yield/plant at the combined analysis are presented in (Table 2 and Fig 1). Kernel ear weight had the most direct effect on grain yield/plant followed by direct effect of ear diameter, ear height and ear length. However, the other direct effects had the lowest effective on grain yield/plant.

The indirect contributions of ear diameter, ear height and ear length to grain yield/plant variation through kernels ear weight were 13.93, 12.76 and 11.03% respectively. Ear height had indirect effect being 3.88% in the total variance of grain yield through ear diameter while it accented 3.13% through ear length. Also, ear length had indirect effect of 3.59% to grain yield variation through ear diameter while, kernel ear weight accounted for 3.34% through 100-kernel weight. Results indicated that the total relative contribution of the studies characters to the variability of grain yield was 92.74% and the residual effect of the other characters was 7.26%. These results are in partial agreement with those obtained by Mohamed and Sedhom (1993), Ashmawy and Mohamed (1998), El-Badawy (2006) and Ahmed *et al.*, (2009).

Table 2: Direct and indirect effects for yield factors of grain yield/plant of maize according to path analysis (Combined over both seasons).

Characters	Direct	CD	RI %
Ear height (X_1)	0.1817	0.0330	2.0229
Ear length (X_2)	-0.1786	0.0319	1.9530
Ear diameter (X_3)	0.1961	0.038	2.3543
No. of kernels/row (X_4)	0.0395	0.0015	0.0959
Kernels ear weight (X_5)	0.6533	0.4269	26.1367
100-kernel weight (X_6)	0.0549	0.0030	0.1849
	Indirect		
X_1 Vs X_2	-0.1409	-0.0512	3.1365
X_1 Vs X_3	0.1747	0.0635	3.8889
X_1 Vs X_4	0.0341	0.0124	0.7604
X_1 Vs X_5	0.5736	0.2085	12.7684
X_1 Vs X_6	0.0445	0.0162	0.9920
X_2 Vs X_3	0.1645	-0.0587	3.5981
X_2 Vs X_4	0.0320	-0.0114	0.7004
X_2 Vs X_5	0.5044	-0.1801	11.0313
X_2 Vs X_6	0.0422	-0.0150	0.9230
X_3 Vs X_4	0.0364	0.0143	0.8754
X_3 Vs X_5	0.5802	0.2275	13.9316
X_3 Vs X_6	0.0461	0.0180	1.1071
X_4 Vs X_5	0.5599	0.0443	2.7143
X_4 Vs X_6	0.0444	0.0035	0.2155
X_5 Vs X_6	0.0418	0.0546	3.3461
Residual		0.1186	7.2624

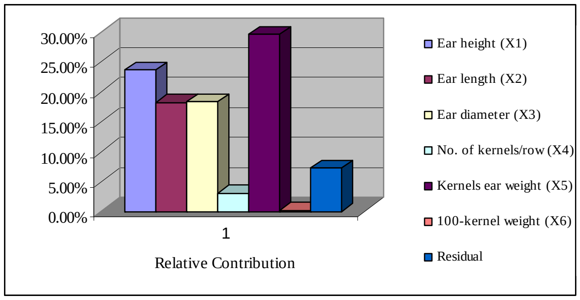

Fig. 1: The percentage of direct and indirect effects of yield attributes in the total variation of maize grain yield.

Multiple Linear Regressions:

Results in Table (3) show the relative contribution of each factor to yield and in predicting seed yield. The prediction equation was formulated as follows:

$Y = -46.916 + 0.257X_1 -1.010X_2 + 4.742X_3 + 0.102X_4 + 1.046X_5 + 0.283X_6$

The relative contribution for all yield factors explained 88.3% of the total variation in grain yield and 11.7% could be due to residual. Ear height, ear length, ear diameter, number of kernels/row, kernels ear weight and 100-kernel weight had the relative contribution of determination (R^2) of 0.51%, 0.78%, 1.14%, 0.02%, 85.7% and 0.09%, respectively of the total yield variance.

Table 3: The relative contribution of 6 characters for predicting yield of maize using multiple linear regression analysis (Combined over both seasons).

Model	Regression Coefficients		t	Sig.	r^2
	B	Std. Error			
Ear height	0.257	0.053	4.828	0.000	0.51
Ear length	-1.010	0.161	-6.271	0.000	0.78
Ear diameter	4.742	1.202	3.946	0.000	1.14
No. of kernels/row	0.102	0.112	0.918	0.359	0.02
Kernels ear weight	1.046	0.057	18.298	0.000	85.70
100-kernel weight	0.283	0.148	1.910	0.057	0.09

Y-Intercept= -46.916 R^2 = 88.3 % Adjusted R^2 = 88.1 %
Multiple R = 0.939 Standard error of estimation = 3.496

Stepwise Multiple Linear Regression Analysis:

Data were subjected to stepwise analysis to determine the significant variables contributing to the variation of grain yield and their relative contribution. Accepted variables and their relative contributing are shown in Table 4. Results revealed that the most contributing variables in grain yield of maize were kernel ear weight, ear height, ear diameter, 100-kernel weight. Those variables were responsible for 88.2% in grain yield variation. It is observed from results that kernel ear weight was the most important variable followed by ear height, ear diameter, ear length and 100-kernel weight, where the relative contributions in the total variability of grain yield in maize were 85.7%, 1.4%, 0.3%, 0.7% and 0.1% for the above mentioned variables, respectively (Table 4). Variable removed was number of kernels/row, which explained 0.1% in the total variability.

The best prediction equation is as follows:

$Y = -47.006 + 1.054X_5 + 0.263X_1 – 0.993X_2 + 5.263X_3 + 0.297X_6$

The major difference between multiple linear regression and stepwise multiple linear regression was that, in the latter, the variable added in each step was the one which made the greatest reduction in the error sum of squares. It was also the one having the highest partial correlation coefficient with the dependent variable for fixed values of those variables added previously. Therefore, one concluded that the order which the variables added was significant. The previous results, revealed that:

1) The accepted variables have to be ranked the first in any breeding program for improving yield.
2) The stepwise multiple linear regressions used to determine the best prediction equation for yield, but it could not explain the interrelationship of the characters measured.

These results are in agreement with those obtained by Shafshak *et al.* (1989), Mohamed and Sedhom (1993), Atia *et al.,* (2001), Ashmawy (2003), El-Badawy (2006) and Ahmed *el al.,* (2009).

Table 4: The relative contribution of characters for explaining grain yield of maize using stepwise multiple regression analysis (Combined over both seasons).

Model	Regression Coefficients		T	Sig.	Cummulative R^2	Partial R^2%
	B	Std. Error				
Kernels ear weight	1.054	0.057	18.604	0.000	0.857	85.7
Ear height	0.263	0.053	4.977	0.000	0.871	1.4
Ear length	-0.993	0.160	-6.207	0.000	0.874	0.3
Ear diameter	5.263	1.059	4.969	0.000	0.881	0.7
100-kernel weight	0.297	0.148	2.012	0.045	0.882	0.1

Y-Intercept= -47.006 R^2 = 88.2% Adjusted R^2 = 88.1%
Multiple R = 0.939 Standard error of estimation = 3.495

Factor Analysis:

A summary of the factor analysis of six variables are given in Table (5). The six variables were grouped into two factors, which explained 90.57% of the total variability in the dependence structure. The composition of variables of the two factors with loadings is given in Table (6). The first factor included the variables ear height, ear length, ear diameter and kernels ear weight, which accounted for 49.16% of the total variances. It had high loadings for four variables. The second factor contributed 41.40% of the total variances indicating.

Table 5: Principal factor matrix after orthogonal rotation for six characters of maize (Combined over both seasons).

Variables	Factors		Communality (h^2)
	Factor I	Factor II	
Ear height	0.794	0.525	0.906
Ear length	0.467	0.813	0.879
Ear diameter	0.748	0.615	0.937
No. of kernels/row	0.748	0.583	0.899
Kernels ear weight	0.871	0.420	0.935
100-kernel weight	0.474	0.809	0.879
Latent roots	2.950	2.485	5.435
Factor variance ratio %	49.162	41.411	90.572

From the previous results, it could be concluded that, factor analysis is the one that can be used successfully for analysis for large amounts of multivariate data and should be applied more frequently in field experiments (Atia *et al.* 2001, Ashmawy 2003 and El-Badawy 2006). The greatest benefit of factor analysis can be delineating areas of further researches designed to test the validity of the suggested factors. Using factor analysis by plant breeders has the potential of increasing the comprehension of causal relationships of variables and can help to determine the nature and sequence of traits to be selected in a breeding program.

Table 6: Summary of factor loading for six variables of maize

Variables	Loading	% of total communality
Factor I		49.162
1- Ear height	0.794	
2- Ear diameter	0.748	
3- No. of kernels/row	0.748	
4- Kernels ear weight	0.871	
Factor II		41.411
1- Ear length	0.813	
2-100-kernel weight	0.809	
Commulative variance		90.572

Generally, path coefficient analysis is used to determine the direct and indirect effect, while stepwise is used to determine the best prediction equation for yield. On the other hand, using factor analysis by plant breeders has the potential of increasing the comprehension of causal relationships of variables and can help to determine the nature and sequence of traits to be selected in breeding program. The results of the analysis techniques indicated that kernels ear weight, ear length, ear diameter, number of kernels/row and 100-kernel weight were the most important contributing variables in the total variability of grain yield/plant. These variables have to be ranked the first in breeding program for improving grain yield of maize.

Effect of Zinc Application:

Data in Table (7) indicate that the spraying of zinc sulphate generally led to significant increases in plant height, stem diameter, ear length, ear diameter, No. of kernels/row, ear weight, kernels ear weight, 100-kernel weight, grain yield/plant and grain yield/fed in both seasons, ear height and No. of ears/plant in the second season. These results may be due to the role of zinc as an essential component for the activity of some dehydrogenases, proteinases and alcohol dehydrogenase (Vallee and Wacher 1970). Similar results were obtained by Hefni *et al.*, (1993a) and Mehasen and Saeed (2006). These increases in the yield components may be due to the increases in number of ears/plant and ear length. Furthermore, the increase in grain yield is mainly due to the increases in yield components. Similar results were obtained by Khalil (1992); Hefni *et al.*, (1993 b) and Ashoub *et al.*, (1996). On the other hand, there were no significant differences in number of rows/ear in both seasons as well as ear height and No. of ears/plant in second seasons as affected by foliar application with zinc sulphate (Table, 6). These results may be due to the fact that these characters are genetically controlled and are not easy to be modified by the other applied environmental factors. Hefni *et al.*, (1993 b) and Mehasen and Saeed (2006) obtained similar conclusions.

Table 7: Effect of zinc spraying on grain yield and its characters of maize in the first and second seasons.

Characters	First season				Second season			
	0	1	2	LSD	0	1	2	LSD
Plant height (cm)	289.8	289.5	292.4	0.7	284.8	285.9	288.9	1.3
Ear height (cm)	152.0	151.6	152.7	NS	143.3	145.9	147.9	0.4
Stem diameter (cm)	1.93	1.94	1.97	0.01	1.86	1.88	1.92	0.01
No. of ears/plant	1.50	1.49	1.50	NS	1.39	1.41	1.50	0.03
Ear length (cm)	18.8	19.9	20.3	0.4	18.2	18.8	19.7	0.5
Ear diameter (cm)	4.49	4.67	4.85	0.06	4.11	4.40	4.51	0.03
No. of rows/ear	12.3	12.4	12.6	NS	12.4	12.5	12.6	NS
No. of kernels/row	45.0	45.9	48.1	0.6	41.4	43.9	45.6	0.8
Ear weight (g)	133.5	134.8	136.2	0.4	126.2	128.0	30.2	0.4
Kernels ear weight (g)	109.2	111.1	113.0	0.3	101.0	102.7	104.5	0.6
100-kernel weight (g)	26.7	27.7	28.4	0.5	25.8	26.6	27.3	0.2
Grain yield/plant (g)	121.0	123.8	126.3	1.9	108.9	110.9	113.3	0.5
Grain yield/fed (kg)	2196	2297	2317	13.28	2120	2173	2219	12.29

Effect of Nitrogen Fertilizer:

Table (8) show that mean values of growth characters and yield components in both seasons were significantly increased by increasing N levels up to 140 or 160 kg N/fed. The highest values of plant height, ear height, stem diameter, No. of ears/plant, ear length, ear diameter, No. of rows/ear, No. of kernels/row, ear weight, kernels ear weight, 100-kernel weight, grain yield/plant and grain yield/fed in the first and second seasons were obtained with fertilizer levels (140 or160 kg N/fed). There were significant responses to nitrogen with characters asserting the vital need for N application to maize production in this soil.

Table 8: Effect of N-level fertilizers on grain yield and its characters of maize in the first and second seasons.

Characters	First season						
	60	80	100	120	140	160	LSD
Plant height (cm)	273.8	281.0	289.4	294.9	300.3	303.9	1.1
Ear height (cm)	143.6	147.2	149.9	153.1	157.8	161.1	0.7
Stem diameter (cm)	1.84	1.88	1.93	1.96	2.01	2.04	0.01
No. of ears/plant	1.20	1.40	1.53	1.60	1.64	1.62	0.04
Ear length (cm)	17.7	18.8	19.5	20.1	20.9	21.1	0.2
Ear diameter (cm)	4.23	4.36	4.51	4.77	5.00	5.15	0.04
No. of rows/ear	11.7	12.2	12.3	12.4	12.9	13.0	0.3
No. of kernels/row	42.6	43.8	45.4	46.9	50. 6	48.8	0.5
Ear weight (g)	122.6	126.2	131.4	142.7	146.5	144.7	0.7
Kernels ear weight (g)	104.0	107.7	111.4	114.2	116.9	114.4	0.7
100-kernel weight (g)	25.1	26.0	27.0	29.9	30.9	30.2	0.2
Grain yield/plant (g)	112.4	116.0	119.4	124.1	137.7	132.6	1.1
Grain yield/fed (kg)	2018	2057	2137	2464	2477	2467	18.5
	Second season						
Plant height (cm)	271.2	277.5	283.0	290.5	296.0	301.0	1.2
Ear height (cm)	136.8	141.1	144.0	147.3	150.7	154.0	0.7
Stem diameter (cm)	1.80	1.83	1.86	1.90	1.94	1.98	0.01
No. of ears/plant	1.22	1.27	1.42	1.54	1.60	1.60	0.07
Ear length (cm)	16.4	17.3	18.4	19.6	20.4	21.2	0.16
Ear diameter (cm)	3.91	4.04	4.19	4.43	4.63	4.85	0.03
No. of rows/ear	11.5	12.0	12.5	12.9	13.2	13.1	0.19
No. of kernels/row	39.6	41.2	42.7	44.5	47.6	46.2	0.4
Ear weight (g)	120.2	121.8	124.6	129.9	140.0	134.3	0.6
Kernels ear weight (g)	96.8	98.7	101.1	103.3	109.7	106.7	0.5
100-kernel weight (g)	24.7	25.5	26.1	27.8	29.0	28.6	0.1
Grain yield/plant (g)	104.0	106.6	109.1	114.4	117.8	116.4	0.5
Grain yield/fed (kg)	1935	1981	2043	2289	2416	2359	12.2

Increasing N-level from 60 to 140 or 160 kg N/fed led to significant increases in grain yield/plant by 20.40 and 17.97%; in 100-kernel weight by 23.10 and 20.31% and in grain yield/fed by 22.74 and 22.20% in the first season and in grain yield/plant by 13.32 and 11.92%; in 100-kernel weight by 17.40 and 15.78% and in grain yield/fed by 24.85 and 21.91% in the second season, respectively. The increases in yield and components may be due to the increases in the growth characters and indirectly affected by N general functions in plant. Russell (1973) stated that the higher the nitrogen supply the more rapidly the synthesized carbohydrates which are converted to proteins and to protoplasm while the small proportion left available for cell wall material. Furthermore, the increase in grain yield/fed is attributed mainly to the increases in yield components. These results are in harmony with those of Ashoub *et al.* (1996); El-Sheikh (1998); Zaghloul (1999); Salem (1999); El-Banna and Gomaa (2000); Sobh *et al.* (2000); El-Banna (2001), El-Wakil (2002) and Mehasen and Saeed (2006).

Interaction Effects:

The interaction between spraying of zinc and N fertilizer levels (Table 9) had significant effect on plant height, ear height, ear length, ear diameter, No. of kernels/row and grain yield/fed in the first and second seasons, stem diameter in the first season and No. of rows/ear, kernels ear weight and grain yield/plant in the second one. The highest values obtained for grain yield plant and fed were detected by spraying with zinc at (0.4% Zn So_4) and applied 140 N/fed while, the lowest values obtained for grain yield plant and fed were detected when applied 60 kg N/fed without spraying of zinc in both seasons.

Table 9: Effect of the interaction between zinc spraying and N-levels on grain yield of maize and its characters in the first and second seasons.

Zn x N	Plant height (cm)	Ear height (cm)	Stem diameter (cm)	Ear length (cm)	Ear diameter (cm)	No. of rows /ear	No. of kernels /row	Wt. of kernels /ear (g)	Grain yield/ plant (g)	Grain yield/ fed (kg)
	First season									
0 x 60	272.6	141.6	1.81	16.7	4.10	11.4	41.4	102.4	110.4	1973
0 x 80	279.7	148.4	1.86	18.0	4.20	12.1	42.3	105.4	113.5	1990
0x 100	291.8	152.0	1.91	18.6	4.29	12.2	44.6	109.3	117.0	2010
0 x 120	294.2	154.2	1.95	19.1	4.56	12.2	45.6	110.8	121.8	2397
0 x140	298.2	156.0	1.99	20.2	4.84	12.8	49. 2	114.7	134.1	2405
0 x 160	302.2	159.9	2.02	20.4	4.93	12.9	47.4	112.7	129.1	2398
1 x 60	274.0	143.8	1.84	17.9	4.19	11.7	42.4	103.8	112.7	2031
1 x 80	280.8	145.1	1.86	18.9	4.35	12.0	43.4	108.2	116.1	2089
1 x 100	285.9	147.2	1.92	19.7	4.55	12.4	44.3	111.9	119.0	2163
1 x 120	293.2	152.0	1.95	20.5	4.74	12.5	46.0	111.8	124.0	2494
1 x 140	299.6	160.1	1.99	21.1	4.97	13.0	50.8	116.9	138.2	2509
1 x 160	303.8	161.6	2.03	21.2	5.18	13.2	48.4	114.3	133.0	2496
2 x 60	274.7	145.2	1.87	18.5	4.39	12.0	44.0	105.9	114.2	2049
2 x 80	282.6	148.2	1.92	19.6	4.51	12.5	45.6	109.5	118.3	2093
2 x 100	290.6	150.5	1.96	20.2	4.68	12.4	47.3	113.0	122.3	2238
2 x 120	297.4	153.0	1.97	20.7	5.00	12.6	49.1	114.0	126.5	2501
2 x 140	303.2	157.4	2.02	21.4	5.18	13.0	52.0	119.2	140.8	2518
2 x 160	305.8	161.7	2.05	21.6	5.33	12.9	50. 7	116.4	135.8	2505
LSD 5%	1.93	1.21	0.01	0.3	0.07	NS	0.8	NS	NS	32.13
	Second season									
0 x 60	268.0	135.0	1.76	15.5	3.82	11.3	38.8	95.8	102.8	1899
0 x 80	275.1	139.3	1.80	16.3	3.92	11.8	39.4	97.1	104.8	1920
0x 100	280.2	141.8	1.82	17.6	4.02	12.5	40.4	99.6	106.8	1997
0 x 120	289.6	144.6	1.86	19.0	4.16	12.8	41.4	101.8	109.8	2215
0 x140	294.8	147.4	1.92	19.9	4.25	13.2	44. 9	107. 3	115. 5	2380
0 x 160	301.3	151.6	1.95	20.9	4.49	13.2	43.6	104.4	114.0	2307
1 x 60	272.4	136.8	1.79	16.4	3.92	11.6	39.4	96.8	103.8	1930
1 x 80	275.7	141.6	1.82	17.4	4.03	11.8	41.3	98.9	106.6	1990
1 x 100	282.6	144.6	1.85	18.4	4.22	12.8	42.8	101.4	109.0	2049
1 x 120	290.2	147.2	1.88	19.4	4.52	12.9	44.8	103.2	112.6	2288
1 x 140	294.4	151.0	1.92	20.4	4.76	13.2	48.6	109. 2	117. 4	2407
1 x 160	300.2	153.9	1.97	21.0	4.94	13.0	46. 6	106.8	116.2	2373
2 x 60	273.3	138.7	1.82	17.4	3.97	11.7	40.6	97.9	105.5	1975
2 x 80	281.7	142.4	1.86	18.4	4.15	12.2	43.1	100.1	108.4	2033
2 x 100	286.4	145.7	1.89	19.4	4.32	12.4	45.0	102.5	111.4	2082
2 x 120	291.8	150.2	1.93	20.3	4.60	13.0	47.2	105.0	114.8	2365
2 x 140	298.9	153.8	1.97	21.0	4.88	13.2	49. 4	112. 6	120.6	2460
2 x 160	301.5	156.6	2.01	21.6	5.10	13.2	48.4	109. 0	119.2	2396
LSD 5%	2.15	1.37	NS	0.3	0.05	0.3	0.7	0.9	0.9	21.10

REFERENCES

Ahmed, M.A.A., S.A.S. Mehasen and A.A. Nuaman, 2009. Multivariate of relating yield components in a set of corn genotypes. *Arab Univ. J. Agric. Sci., Ain Shams Univ.*, 17(1): 95-102.

Ashmawy, F. and N.A. Mohamed, 1998. Comparison among some statistical procedures in estimating yield and its components in maize. J. Agric. Sci. Mansoura Univ., 23(5): 1873-1879.

Ashmawy, F., 2003. Using some multivariate proceures and response curve analysis in maize. J. Agric. Sci. Mansoura Univ., 28(10): 7107-7121.

Ashoub, M.A., M.S. Hassanein, I.M.A. Abdel-Aziz, M.M. Shahin and M.N. Gohar, 1996. Influence of irrigation, nitrogen, zinc and manganese fertilization on yield and yield components of maize. Annals Agric. Sci., Ain Shams Univ., Cairo, 41(2): 697-711.

Atia, A.A.M., K.A. Eldouby, M.M. Salem and A.M.S.A. Eltaweel, 2001. Factor analysis and other statistical techniques efficiencies for studying yield and yield components in maize (*Zea mays* L.). Conference of Sustainable Agricultural Development, Fayoum, Fac. Agric., cairo Univ., 46-53.

Cattel, R.B., 1965. Factor analysis: An introduction to essentials. 1- The purpose and underlying models. Biometrics, 21: 195-215.

Dewey, D.R. and K.H. Lu, 1959. A correlation and path coefficient analysis of components of crested wheat grass seed production. Agron. J., 51: 515-518.

Draper, N.R. and H. Smith, 1966. Applied Regression Analysis. John Wilay and Sons, New York.

Duarte, R.A. and M.W. Adams, 1972. A path coefficient analysis of some yield components interrelation in field beans (*Phaseoleus vulgaris* L.). Crop Sci., 12(5): 579-582.

El-Badawy, M.El.M., 2006. The relative contribution of yield components by using specific statistical techniques in corn. Annals of Agric. Sci., Moshtohor, 44(3): 899-909.

El-Banna, A.Y. and M.A. Gomaa, 2000. Effect of N and K fertilization on maize grown in different populations under newly reclaimed sandy soil. Zagazig J. Agric. Res., 27(5): 1179-1196.

El-Banna, A.Y.A., 2001. Effect of nitrogen fertilization and stripping leaves on yield and yield attributes of two maize (*Zea mays* L.) hybrids. Zagazig J. Agric. Res., 28(3): 579-596.

El-Kalla, S.E. and F.M. El-Rayes, 1984. Multivariate analysis of yield and the relative contribution of variables to its variations in maize (*Zea mays*). 2nd Conf. A.R.C., Giza, 62(7): 1-13.

El-Sheikh, F.T., 1998. Effect of plant population densities on nitrogen use efficiency of some maize varieties. Annals. Agric. Sci., Moshtohor, 36(1): 143-162.

El-Wakil, N.M.H., 2002. Response of some cultivars of maize to plant density and nitrogen fertilization. M.Sc. Thesis, Fac. Agric. Moshtohor, Zagazig Univ., Egypt.

Hefni, E.H.M., A.A. El-Hosary, M.I.M. Salwau and A. El-Sabbagh, 1993. a. Effect of soil moisture stress and foliar application of zinc on some maize varieties. I-Growth measurements. Annals of Agric. Sci. Moshtohor, 31(4): 1813-1828.

Hefni, E.H.M., A.A. El-Hosary, M.I.M. Salwau and A. El-Sabbagh, 1993b. Effect of soil moisture stress and foliar application of zinc on some maize varieties. II-Yield components and chemical analysis. Annals of Agric. Sci. Moshtohor, 31(4): 1829-1846.

Khalil, A.M.A., 1992. Effect of nitrogen, zinc and farmyard manure on yield of maize. M.Sc. Thesis, Fac. Agric., Moshtohor, Zagazig Univ., Egypt.

Mehasen, S.A.S. and N.A. Saeed, 2006. Performance of three maize hybrids under spraying with zinc and nitrogen fertilization. *Annals of Agric. Sci., Moshtohor,* 44(3): 887-897.

Mohamed, M.K. and S.A. Sedhom, 1993A. comparison between four statistical procedures of relating yield components in a set of corn varieties. Annals of Agric. Sc., Moshtohor, 31(4): 1855-1866.

Russell, E.W., 1973. Soil conditions and plant growth. 10th Edit., Longman, Gkoup LTD, Pp: 31-37.

Salama, F.A., S.H.F. Aboul-Saad, F.H. Soliman and S.E. Sadek, 1994. Correlation and path coefficient analysis in eight yellow maize (*Zea mays* L.) hybrid characters. Menofya J.Agric. Res.,19: 3035-3047.

Salem, M.A., 1999. Response of maize plants to drought and nitrogen fertilization. Minia. Agric. Res. Develop, 19(2): 183-206.

Shafshak, S.E., A.A. Abd El-Halim, A.M.M. Saad and F.A. Ahmed, 1989. Integrated regression analysis of maize yield factors using minimum sample size. Egypt. J. Apple. Sci., 4: 1855-1866.

Snedecor, G.W. and W.G. Cochran, 1981. Statistical Methods. Seventh. Edition. Iowa State Univ., Press, Ames, Iowa, USA.

Sobh, M.M., Wagdi Abd El-Hamid and M. Gouda, 2000. Yield and chemical composition of maize as affected by macronutrients fertilization. Zagazig J. Agric. Res., 27(1): 159-169.

Soliman, F.H., G.A. Morshed, M.M.A. Ragheb and M.K.H. Osman, 1999. correlation and path coefficient analysis in four yellow maize hybrids grown under different levels of plant population densities and nitrogen fertilization. Bull. Fac. Agric., Cairo Univ., 50: 639-658.

Steel, R.G.D. and J.H. Torrie, 1987. Principles and Procedures of Statistics. A Biometrical Approach. 2nd Ed. 6th printing. Mc. Graw. Hill BooK company. USA: 272-277.

Vallee, B.L. and W.E.C. Wacher, 1970. Metalloproteinase in the protein by H. Neurath. Vol 5 pp. 61-66. Academic Press. New York.

Zaghloul, A.K.A., 1999. Effect of nitrogen and Biogas fertilizers on maize and the following wheat yield. Ph.D. Thesis, Fac. Agric. Moshtohor, Zagazig Univ., Egypt.