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EFFECT OF PLANTING DENSITY AND NITROGEN FERTILIZATION ON YIELD AND IT'S ATTRIBUTES OF SOME YELLOW MAIZE HYBRIDS

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ABSTRACT

This investigation was conducted for two seasons (2009 and 2010) in the Agric. Experiment Station (Ghazala location), Fac. of Agric., Zagazig Univ., Egypt, to find out the response of three yellow maize hybrids (SC 162, SC 166 and TWC 352) to three planting densities (30, 25 and 20 thousand plants/fad.), and three N fertilization levels (40, 80 and 120 kg N/fad.).Significant varietal differences were detected in the final yields/fad., from; ear, stover, above-ground biomass and grain and most of their attributes, where SC 166 hybrid recorded significantly the highest averages followed by SC 162 and TWC 352 in descending order. On individual plant basis, the thinnest planting density (20 000 plants/fad.) recorded the highest averages, but on land area basis the thickest density (30 000 plants/fad.) recorded the highest above-ground biomass, stover and grain yields/fad., but however the lowest harvest index. The three maize hybrids responded to each increase in N level up to 120 kg N /fad., where the high N fertilized plants had longer ears with larger number of rows /ear and as well heavier grain index and in turn heavier grain weight/ear. Significant interactions could be detected by each two of the three factors under study indicating varietal response to each of planting density and N level. These interactions showed that, dense sown plants were always in need for higher N level where the highest averages were recorded for thickest planting density and the highest N level. According to simple correlation, the final grain yield/fad., correlated strongly with all of it's attributes. Also, the path analysis results showed that ear length, ear weight and grain index and their interactions, in general, were the main sources of grain yield variations since, the path coefficients were of highly association values with grain yield and they contributed by 92.52% of the total yield variations.

Keywords: Yellow maize hybrids, N fertilization, planting density, yield and it's attributes.

INTRODUCTION

Maize (*Zea mays*, L.) is one of the most widely grown cereals in the world. It has a good potential side by side with wheat and rice. In Egypt, the amount of maize grains required for human consumption, animal and poultry feeding (yellow grains of highly nutritional status) and other industrial products (starch, protein, fibre, ash and oil) is greater than that local production. Therefore, the major concern of Agronomists is to maximize yields of maize hybrids (yellow) by applying the most suitable options, among them: planting density and N fertilization.

Many research workers documented significant cultivar variations regarding yield and it's contributing traits, such as : El-Zeir *et al.* (1998) as they showed marked differences between SC 129 and TWC 320 hybrids concerning ear diameter, row number/ear, grain number/row, grain index and grain yield/plant as well as/fad., where the SC 129 was pioneer in this regard. Also, Abd El-Maksoud and Sarhan (2008) reported that the TWC 310 cultivar was superior than both SC 10 and SC 122 as for: ear length, number of grains/ear, grain index, grain yield either/plant or/fad., biomass and HI. Similar cultivar differences were documented by Said and Gabr (1999) and Hassan *et al.* (2008).

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The planting density is among the major factors considered for optimizing maize grain yield and it's related parameters. In this connection, Badr *et al.* (1993) showed that the 30 thousand plants density/fad., surpassed markedly both the 25 and 20 thousand plants/fad., in final yields/fad. The reverse hold true as for the rest of maize yield attributes, since the lowest density was superior in this connection. Identical trends were reported by other research workers, of them : Soliman *et al.* (1995), Said and Gabr (1999), El-Bana and Gomaa (2000), El-Mekser *et al.* (2009) and Hoshang (2012) as they obtained significant augmentation in final grain yields/unit area in favour of the highest plant density used.

Nitrogen is considered the most important nutrient for monitoring many physiological processes in maize plants responsible for enhancing final yields/unit land area. Atia (2006) concluded that the 120 kg N level/fad., detected positive and significant augments as for maize ear height, ear diameter, ear length, number of grains/row and the final yields/fad., from (ear, straw and biomass), grain index as well as crop and harvest indices compared with both 40 and 80 kg N levels and the check treatments. But, shelling% increase was in favour of the un-fertilized control. Other workers emphasized the tendency of maize yield increases due to raising N levels, of them : Said *et al.* (1996), Said and Gabr (1999), El-Douby *et al.* (2001), Ash-Shormillesy (2005), Vania *et al.* (2010), Allah *et al.* (2011), Hoshang (2012) and Moraditochaee *et al.* (2012).

Ash-Shormillesy (2005) recorded positive and significant relations between maize grain yield/fad., and each of : plant as well as ear heights, stalk diameter, ear diameter, ear length, number of rows/ ear, grain number/row and/ear, grain index and shelling%. Also, positive and significant associations were seen between any pairs of the above-named characters. Similar correlation results were found by : El-Bana (2001), Atia (2006) and Moraditochaee *et al.* (2012).

Regarding path analysis study, Ghanem (1988) showed that the main sources in maize grain yield variations were grain number/row, ear length and the joint effect of grain number/row with both ear length and grain index, where the direct and joint effects contributed about 97.95% of the total maize grain yield diversities. Salama *et al.* (1994), Ash-Shormillesy (2005) and Moraditochaee *et al.* (2012) documented similar path analysis results.

At last, this study was conducted to find out the impact of planting density and N fertilization on grain yield and it's contributing parameters of three yellow maize hybrids.

MATERIALS AND METHODS

Two field trials were planned in the Agric. Exp. Station (Ghazala Location) during the summer season of 2009 and 2010 to find out the influence of planting density and N fertilization levels on the yield and it's attributes of three yellow maize hybrids. The preceding crop was wheat in both seasons. Soil sample was taken from the upper 30 cm soil surface before planting and the physio-chemical analysis of the soil showed that the soil was clay loam in texture having : sand of 23.90 and 23.70%, silt of 9.30 and 9.20%, clay of 43.50 and 43.15%, organic matter of 0.40 and 0.52%, available N of 18 and 23 ppm, available P of 24 and 36 ppm, available K of 146 and 155 ppm and pH of 7.62 and 7.81 for first and second seasons, respectively.

The Studied Factors Were as Follows

Maize cultivars (hybrids), V

a. Single cross 162 (SC 162), V_1.

b. Single cross 166 (SC 166), V_2.

c. Three way cross 352 (TWC 352), V_3.

The three yellow maize hybrids were released by Maize Res. Dept., Agric. Res. Centre, Cairo, Egypt.

Planting density (plant stand), D

Three plant densities used through changing the spaces between hills as follows keeping one plant /hill at thinning and 70 cm spaced ridges:

a. 30 000 plants/fad., keeping from 20 cm between hills, D_1.

b. 25 000 plants/fad., keeping from 24 cm between hills, D_2.

c. 20 000 plants/fad., keeping from 30 cm between hills, D_3.

Nitrogen fertilization levels, N

Three N levels examined were:

a. 40 kg N/fad., N_1.

b. 80 kg N/fad., N_2.

c. 120 kg N/fad., N_3.

Each N level was applied in 3 equal parts just before the first, second and third irrigations, orderly in the form of urea (46.5% N).

A split-plot design with 3 replicates was used in this study, where the combinations between the 3 hybrids and the 3 planting densities were assigned in the main plots, whereas the sub-plots were occupied by the 3 N levels. The net area of each sub-plot was 12.6 m^2 (4.2 x 3 m including 6 ridges). The 2 outer ridges were left to avoid the border effects, whereas the plants of the 4 central ridges were used to determine yield and it's attributes.

The grains of cultivars were hand planted by Afir (dry) method on May 20th in both seasons. Before planting, the grains were treated by the recommended fungicides to avoid a possible harmful effect of soil diseases. Thinning was done to one plant/hill before first irrigation (20 days from sowing) when crop attained 15 cm height (3-4 leaves stage). Ordinary calcium super-phosphate (15.5% P_2O_5) and potassium sulphate (48-52% K_2O) fertilizers were applied as one dose for all plots before planting at level of 15 kg P_2O_5 and 25 kg K_2O. Other agricultural practices were made as it when necessary to keep the crop free from weeds and to protect from diseases. Harvesting was done on 20th September in both seasons.

Recorded Data

At harvest, samples each of five plants were taken randomly from the fifth ridge in each sub-plot, so the following yield attributes were recorded:

Ear length (cm), number of rows/ear, number of grains/row, ear weight (g), grain weight/ear (g) and 100-grains weight (grain index), g.

Thereafter, a bulk sample including all maize plants found in an area of 4.2 m^2 was harvested from the third and fourth central ridges in each sub-plot, then the following measurements were documented:

Ear yield/fad., (ton), stover yield/fad., (ton), above-ground biomass yield/fad., (ton) and grain yield/fad., (ton).

Each of ear, stover, above-ground biomass yield/fad., and grain yields were estimated firstly as kg per 4.2 m^2, then converted to ton/fad.

Grain yield/fad., was adjusted to 15.5% grain moisture content. Also, shelling percentage and harvest index were estimated as follows:

Shelling percentage (%)

$$= \frac{\text{Kernels weight/ear in g}}{\text{Weight of ear in g}} \times 100$$

Harvest index (HI), %

$$= \frac{\text{Grain yield in ton/fad.}}{\text{Above-ground biomass yield in ton/fad.}} \times 100$$

Yield Analysis Study

Simple correlation

On combined data basis, a simple correlation coefficient between grain yield/fad., and each of it's related characters was calculated according to Svab (1973).

Path analysis

In the pooled data, the path coefficient analysis was practised by partitioning the simple correlation coefficient between maize grain yield/ fad., and it's components, being ear length, ear weight and 100-grains weight as documented by Li (1975).

Statistical Analysis

The results of all studied characters of both seasons and their combined were statistically analyzed by using Computer Software MSTAT-C as described by Freed and Scott (1986).

The significant averages were compared by using the Duncan Multiple Range Test at 5 and 1% levels of probability (Duncan, 1955).

Likewise, Bartlett test for the homogeneity of errors variance was calculated between the error mean squares of the 2 seasons and was found to be insignificant. Therefore, the combined analysis had been done for all the studied characters. Means denoted by similar letter(s) are not significantly different. In interaction Tables, capital and small letters were used to compare both row and column averages, orderly. *,** and N.S. denote to significant and highly significant differences among means at 5 and 1% levels of probability and insignificant variations, respectively.

RESULTS AND DISCUSSION

Cultivar Differences

The results listed in Tables 1 to 4 clear significant cultivar variations in all maize studied traits in both seasons and over them. It is obvious that the TWC 352 hybrid had larger number of rows/ear as well as heavier grain index when compared with the other two hybrids tested. On the other hand, the SC 166 maize hybrid possessed significantly greater mean averages than both SC 162 and TWC 352 ones in most agronomic parameters of maize, being: ear length, number of grains/row, ear weight, grain weight/ear, the final yields per fad., from ear, stover, biomass as well as grain, shelling percentage and harvest index. Such observation was clearly manifested in both seasons and their combined data too. The cultivar differences in all the studied traits of maize may be ascribed to the genetical differences among them, which play an important role for exploiting the uptake of the available nutrients and photosynthesis process leading to much noticeable changes of the metabolites accumulated in maize shortage organs. On the other hand, the results clearly indicated that the SC 166 hybrid had a broader genetic base that helped it to be more responsive to agricultural options and environmental conditions prevailing in the surrounding media of the experimentation. Similar maize cultivar performance as for the final yields per unit area and their attributes were documented by El-Zeir *et al.* (1998), Said and Gabr (1999) and Hassan *et al.* (2008).

Planting Density Effect

Results in Tables 1 to 4 clearly revealed significant changes in most maize yield and it's related characters due to changing in hill spacing (planting density) in both seasons as well as in their pooled data. It is obvious that the lowest plant stand of 20 000 plants/fad., gave marked increases in each of : ear length, number of grains/row, ear weight, grain weight/ear and 100-grains weight relative to both 25 000 and 30 000 plants/fad. Such favourable effect on individual plant attributes under this low stand, could be interpreted on the basis that, the maize plants grown at 20 000 plant/fad., had more advantage with both land and solar radiation uses reflecting positive increases in such above named maize traits.

At the same-time, the results showed insignificant changes in both number of rows/ ear and shelling % due to the plant density variation in both seasons and over them (Tables 1 to 4). Moreover, the dense sown plants of 30 000 plants/fad., had greater mean values in the final yields/fad., from (ear, stover, above-ground biomass, grain) and harvest index. Such effect was also noticed in both seasons and in their combined data. It could be concluded that the 30 000 plants stand density, increased the final maize yields per unit land area, in spite of the reduction in individual yield parameters recorded herein, such as ear length, number of grains/row … etc. under such higher density. This increase may be mainly attributed to the increase of actual number of plants/fad., at harvest. The results of other workers, Badr *et al.* (1993), Soliman *et al.* (1995), Said and Gabr (1999), El-Bana and Gomaa (2000), El-Mekser *et al.* (2009) and Hoshang (2012) emphasized such trend.

Nitrogen Fertilization Level Effect

Significant variations were observed between N levels tested as for all maize characters studied in both seasons and the combined analysis (Tables 1-4). The application of 40 kg N/fad., was met by increasing maize harvest index only followed by 80 and 120 kg N/fad., levels. Furthermore, adding 120 kg N/fad., brought about marked increases in most maize attributes and yields/unit land area, being: ear length, number of rows/ear, number of grains/ row, ear weight, grain weight/ear, 100-grains weight, the yields/fad., from (ear, stover, biomass and grain) and at last shelling % if

Table 1. Ear length, number of rows/ear and number of grains/row of three maize hybrids as affected by planting density and N levels and their interactions in 2009 and 2010 seasons

Treatments	Ear length (cm)			Number of rows/ear			Number of grains/row		
	2009 season	2010 season	Combined	2009 season	2010 season	Combined	2009 season	2010 season	Combined
Cultivars, V									
SC 162	21.72b	19.36b	20.54 b	14.59 c	13.01 c	13.80 c	42.65 b	38.97 b	40.81 b
SC 166	23.99a	22.99a	23.49 a	15.41 b	15.15 b	15.28 b	44.08 a	42.66 a	43.37 a
TWC 352	19.06c	17.32c	18.19 c	16.23 a	16.69 a	16.46 a	37.44 c	36.66 c	37.05 c
F.test	*	**	**	*	**	**	**	**	**
Planting density, D									
30 000 plants/fad.	19.80c	17.68c	18.74 c	15.28	15.04	15.16	39.74 c	36.48 c	38.11 c
25 000 plants/fad.	20.19b	20.01b	20.10 b	15.38	14.90	15.14	40.56 b	39.16 b	39.86 b
20 000 plants/fad.	24.78a	21.98a	23.38 a	15.57	14.91	15.24	43.87 a	42.65 a	43.26 a
F.test	**	*	**	N.S.	N.S.	N.S.	*	**	**
N levels (kg N/fad.), N									
40	18.94c	17.42c	18.18 c	14.41 c	13.93 c	14.17 c	37.70 c	36.10 c	36.90 c
80	21.38b	19.96 b	20.67 b	15.16 b	15.28 b	15.22 b	41.62 b	39.06 b	40.34 b
120	24.45a	22.29 a	23.37 a	16.66 a	15.64 a	16.15 a	44.85 a	43.13 a	43.99 a
F.test	**	*	**	**	**	**	**	**	**
Interactions									
V × D	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
V × N	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	*	N.S.	N.S.
D × N	*	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
V × D × N	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

Table 2. Ear weight, grain weight/ear and 100-grains weight of three maize hybrids as affected by planting density and N levels and their interactions in 2009 and 2010 seasons

Treatments	Ear weight (g)			Grain weight/ear (g)			100-grains weight (g)		
	2009 season	2010 season	Combined	2009 season	2010 season	Combined	2009 season	2010 season	Combined
Cultivars, V									
SC 162	273.62 b	261.00 b	267.31 b	239.54 b	223.10 b	231.32 b	41.34 c	34.76 c	38.05 c
SC 166	289.90 a	279.70 a	284.80 a	251.72 a	241.78 a	246.75 a	43.12 b	37.52 b	40.32 b
TWC 352	268.56 c	246.86 c	257.71 c	226.19 c	216.27 c	221.23 c	48.44 a	40.04 a	44.24 a
F.test	**	**	**	**	**	**	**	*	**
Planting density, D									
30 000 plants/fad.	254.04 c	249.08 c	251.56 c	224.19 c	214.59 c	219.39 c	40.74 c	33.58 c	37.16 c
25 000 plants/fad.	283.67 b	263.59 b	273.63 b	240.07 b	230.37 b	235.22 b	44.12 b	37.32 b	40.72 b
20 000 plants/fad.	294.37 a	274.89 a	284.63 a	253.19 a	236.19 a	244.69 a	48.04 a	41.42 a	44.73 a
F.test	**	**	**	**	**	**	**	**	**
N levels (kg N/fad.), N									
40	260.85 c	249.81 c	255.33 c	218.85 c	209.01 c	213.93 c	41.63 c	33.35 c	37.49 c
80	276.85 b	260.89 b	268.87 b	243.96 b	227.62 b	235.79 b	44.63 b	37.07 b	40.85 b
120	294.38 a	276.86 a	285.62 a	254.64 a	244.52 a	249.58 a	46.64 a	41.90 a	44.27 a
F.test	**	**	**	**	**	**	**	**	**
Interactions									
V × D	N.S.	N.S.	N.S.	N.S	N.S.	N.S.	N.S.	N.S.	N.S.
V × N	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	*	N.S.	*(2-b)
D × N	N.S.	N.S.	N.S.	*	N.S.	*(2-a)	N.S.	N.S.	N.S.
V × D × N	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

Table 3. The final yields/fad., from ear, stover and above-ground biomass of three maize hybrids as affected by planting density and N fertilization levels and their interactions in 2009 and 2010 seasons

Treatments	Ear yield/fad. (ton)			Stover yield/fad. (ton)			Above-ground biomass/fad. (ton)		
	2009 season	2010 season	Combined	2009 season	2010 season	Combined	2009 season	2010 season	Combined
Cultivars, V									
SC 162	4.88 b	4.36 b	4.62 b	5.00 b	4.90 b	4.95 b	9.88 b	9.26 b	9.57 b
SC 166	5.06 a	4.86 a	4.96 a	5.41 a	5.29 a	5.35 a	10.53 a	10.15 a	10.34 a
TWC 352	4.67 c	4.13 c	4.40 c	4.74 c	4.60 c	4.67 c	9.41 c	8.73 c	9.07 c
F.test	*	*	*	*	**	*	*	*	*
Planting density, D									
30 000 plants/fad.	5.86 a	5.10 a	5.48 a	6.07 a	5.73 a	5.90 a	11.93 a	10.83 a	11.38 a
25 000 plants/fad.	4.92 b	4.44 b	4.68 b	5.02 b	5.16 b	5.09 b	9.94 b	9.60 b	9.77 b
20 000 plants/fad.	3.83 c	3.81 c	3.82 c	4.06 c	3.90 c	3.98 c	7.95 c	7.71 c	7.83 c
F.test	**	**	**	**	**	**	**	**	**
N levels (kg N/fad.), N									
40	3.84 c	4.02 c	3.93 c	4.32 c	4.14 c	4.23 c	8.22 c	8.16 c	8.19 c
80	4.90 b	4.38 b	4.64 b	4.95 b	4.91 b	4.93 b	9.85 b	9.29 b	9.57 b
120	5.87 a	4.95 a	5.41 a	5.88 a	5.74 a	5.81 a	11.75 a	10.69 a	11.22 a
F.test	**	**	**	**	**	**	**	**	**
Interactions									
V × D	N.S.	N.S.	N.S.	N.S.	*	*(3-c)	*	N.S.	*(3-e)
V × N	*	N.S.	*(3-a)	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
D × N	*	*	*(3-b)	*	*	*(3-d)	*	*	*(3-f)
V × D × N	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

Table 4. Grain yield/fad., shelling percentage and harvest index (HI) of three maize hybrids as affected by planting density and N fertilization levels and their interactions in 2009 and 2010 seasons

Treatments	Grain yield/fad. (ton)			Shelling %			Harvest index (%)		
	2009 season	2010 season	Combined	2009 season	2010 season	Combined	2009 season	2010 season	Combined
Cultivars, V									
SC 162	4.21 b	3.77 b	3.99 b	86.54 b	85.48 b	86.01 b	42.61 b	41.01 b	41.81 b
SC 166	4.56 a	4.30 a	4.43 a	87.83 a	87.45 a	87.64 a	43.30 a	43.26 a	43.28 a
TWC 352	3.95 c	3.51 c	3.73 c	84.23 c	85.49 c	84.86 c	41.98 b	40.08 b	41.03 b
F.test	**	*	**	*	*	*	*	*	*
Planting density, D									
30 000 plants/fad.	5.22 a	4.30 a	4.76 a	86.25	86.15	86.20	44.14 a	42.68 a	43.41 a
25 000 plants/fad.	4.20 b	3.82 b	4.01 b	86.35	85.85	86.10	42.25 b	40.79 b	41.52 b
20 000 plants/fad.	3.30 c	3.46 c	3.38 c	86.00	86.42	86.21	41.50 c	40.88 b	41.19 b
F.test	**	**	**	N.S.	N.S.	N.S.	**	**	**
N levels (kg N/fad.), N									
40	3.80 c	3.42 c	3.61 c	83.90 c	83.68 c	83.79 c	44.88 a	42.82 a	43.85 a
80	4.30 b	3.68 b	3.99 b	86.10 b	86.24 b	86.17 b	43.65 b	39.61 b	41.63 b
120	4.62 a	4.48 a	4.55 a	88.60 a	88.50 a	88.55 a	39.36 c	41.92 c	40.64 c
F.test	**	**	**	**	**	**	**	**	**
Interactions									
V × D	*	N.S.	*(4-a)	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
V × N	*	*	*(4-b)	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
D × N	*	*	*(4-c)	N.S.	N.S.	N.S.	*	N.S.	*(4-d)
V × D × N	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

compared with both 80 and 40 kg N levels. The soil fertility level of the experimental site was very low from available N which ranged from 18 to 23 ppm due to it's very poor content from organic matter (0.40 – 0.52%). This low fertility level could account for the response of maize to the increase of N level up to 120 kg N/fad. Application of N might have had enhanced photosynthesis metabolites and hence more were available and had a direct effect on maize plant organs development, resulting in increased all yield attributes and the consequent yields per unit land area. In other meaning, application of 120 kg N/fad., gave a favourable effect on maize yield components, reflecting, therefore better yields per unit land area. The promoted effect of N fertilization, to a limited level, and on different maize genotypes as for yield and it's related parameters was documented by some research workers, such as Said *et al.* (1996), Said and Gabr (1999), El-Douby *et al.* (2001), Ash-Shormillesy (2005), Atia (2006), Vania *et al.* (2010), Allah *et al.* (2011), Shirazi *et al.* (2011), Hoshang (2012) and Moraditochaee *et al.* (2012).

Interaction Effect

According to the combined data, it is clear that the three yellow maize hybrid interacted positively with planting density used, since the SC 166 hybrid grown at dense planting of 30 000 plants/fad., got greater mean records in the final yields /fad., from stover, above-ground biomass and grain (Tables 3-c, 3-e and 4-a, respectively). Likewise, the tested hybrids studied reflected significant interaction effects along with the 3 N levels applied in grain index, where the SC 166 was superior in this connection when the 120 kg N level was practiced (Table 2-b) In addition, the same N level (120 kg N/fad.) used for fertilizing SC 166 hybrid detected marked increases regarding both ear and grain yields/ fad., (Table 3-a and 4-b, respectively). Furthermore, the 3 planting densities interacted substantially with the 3 N levels applied as for grain weight/ear, where the lighter stand of 20 000 plants/fad., beared heavier grains /ear by considering the 120 kg N level /fad. (Table 2-a). Moreover, the interacting effect of planting density and N levels was greatly observed regarding the final yields /fad., from: ear, stover, above-ground biomass and grain revealing the superiority of denser planting of 30 000 plants /fad., when 120 kg N level /fad., was concerned (Tables 3-b,3-d, 3-f, 4-c, respectively). At last, the maize harvest index significantly influenced by the D X N interaction (Table 4-d) where the highest HI was recorded due to dense planting (30 000 plants/fad., and shortage in added N (40 kg N/fad.). This refers to intensive competition between the dense sown plants for N and hence their vegetative growth was restricted but was in favour of grain yield, therefore HI was increased. In a short, it could be concluded from the results of interaction effects that, the combined treatment of 30 000 plants/fad., was more pronounced in boosting the final yields/ fad., when the 120 kg N /fad was practiced, and such effect was completely true for the 3 hybrids used, being more notable for the SC 166 one, alluding for the preferable recommendation of growing such hybrid using treatments under Zagazig location, Sharkia Governorate, Egypt.

Yield Analysis Study

Simple correlation coefficient

The results listed in Table 5 clearly reveal positive and significant relations between maize grain yield/fad., on one hand and each of : ear length, number of rows/ear, grain number/row, ear weight, grain weight/ear, grain index, the yields/fad., from (ear, straw and biomass), shelling % and HI. Likewise, positive and strong associations were documented between any pairs of the studied characters, clearing the useful indication to the efficacy of the studied treatments in raising the yield attributes ending to improving and maximizing the final grain yield/fad., for the tested yellow maize hybrids (SC 162, SC 166 and TWC 352), being more preferable as for SC 166 cultivar. Similar views were documented by other research workers, among them : El-Bana (2001), Ash-Shormillesy (2005), Atia (2006) and Moraditochaee *et al.* (2012).

Path analysis study

The partitioning of simple correlation coefficient between maize grain yield/fad., and it's components (ear length, ear weight and grain index) is summarized in Table 6. It is obvious that ear length, ear weight and grain index had considerable direct effects on grain yield/fad., Viz : 0.530, 0.470 and 0.416, orderly. Also, the indirect effect of ear weight via ear length or in the reverse

Table 2-a. Ear weight/fad., of maize as affected by the D × N interaction (combined data)

N levels (kg N/fad.), N \ Planting density, D	30 000 plants fad.$^{-1}$	25 000 plants fad.$^{-1}$	20 000 plants fad.$^{-1}$
	C	B	A
40	195.48 c	211.52 c	234.79 c
	C	B	A
80	217.72 b	242.28 b	247.37 b
	B	A	A
120	244.97 a	251.86 a	251.91 a

Table 2-b. 100-grains weight of maize as affected by the V × N interaction (combined data)

N levels (kg N/fad.), N \ Cultivars, V	SC 162	SC 166	TWC 352
	C	B	A
40	35.47 c	36.78 c	40.22 c
	C	B	A
80	37.55 b	40.00 b	45.00 b
	C	A	A
120	41.13 a	44.18 a	47.50 a

Table 3-a. Ear yield/fad., of maize as affected by the V × N interaction (combined data)

N levels (kg N/fad.), N \ Cultivars, V	SC 162	SC 166	TWC 352
	B	A	B
40	3.80 c	4.20 c	3.79 c
	B	A	C
80	4.70 b	5.00 b	4.22 b
	B	A	C
120	5.36 a	5.68 a	5.19 a

Table 3-b. Ear yield/fad., of maize as affected by the D × N interaction (combined data)

N levels (kg N/fad.), N \ Planting density, D	30 000 plants fad.$^{-1}$	25 000 plants fad.$^{-1}$	20 000 plants fad.$^{-1}$
	A	B	C
40	4.40 c	4.10 c	3.29 c
	A	B	C
80	5.40 b	4.70 b	3.82 b
	A	B	C
120	6.64 a	5.24 a	4.35 a

Table 3-c. Stover yield/fad., of maize as affected by the V × D interaction (combined data)

Planting density, D \ Cultivars, V	SC 162	SC 166	TWC 352
30 000 plants/fad.	B 5.90 a	A 6.20 a	C 5.60 a
25 000 plants/fad.	B 5.00 b	A 5.30 b	B 4.97 b
20 000 plants/fad.	B 3.95 c	A 4.55 c	C 3.44 c

Table 3-d. Stover yield/fad of maize as affected by the D × N interaction (combined data)

N levels (kg N/fad.), N \ Planting density, D	30 000 plants/fad.	25 000 plants/fad.	20 000 plants/fad.
40	A 5.62 b	B 3.95 c	C 3.12 c
80	A 5.68 b	B 5.32 b	C 3.79 b
120	A 6.40 a	B 6.00 a	C 5.03 a

Table 3-e. Above-ground biomass yield/fad., of maize as affected by the V × D interaction (combined data)

Planting density, D \ Cultivars, V	SC 162	SC 166	TWC 352
30 000 plants/fad.	B 11.40 a	A 11.80 a	C 10.94 a
25 000 plants/fad.	B 10.00 b	A 10.40 b	C 8.91 b
20 000 plants/fad.	B 7.31 c	A 8.82 c	B 7.36 c

Table 3-f. Above-ground biomass yield /fad., of maize as affected by the D × N interaction (combined data)

N levels (kg N/fad.), N \ Planting density, D	30 000 plants/fad.	25 000 plants/fad.	20 000 plants/fad.
40	A 9.49 c	B 7.21 c	C 7.87 c
80	A 11.45 b	B 10.00 b	C 7.26 b
120	A 13.20 a	B 12.10 a	C 8.36 a

Table 4-a. Grain yield/fad., of maize as affected by the V × D interaction (combined data)

Planting density, D \ Cultivars, V	SC 162	SC 166	TWC 352
	B	A	C
30 000 plants/fad.	4.60 a	5.20 a	4.48 a
	B	A	C
25 000 plants/fad.	3.98 b	4.45 b	3.60 b
	B	A	C
20 000 plants/fad.	3.39 c	3.64 c	3.11 c

Table 4-b. Grain yield/fad., of maize as affected by the V × N interaction (combined data)

N levels (kg N/fad.), N \ Cultivars, V	SC 162	SC 166	TWC 352
	B	A	C
40	3.60 c	3.90 c	3.33 c
	B	A	C
80	4.00 b	4.50 b	3.47 b
	B	A	B
120	4.37 a	4.89 a	4.39 a

Table 4-c. Grain yield/fad., of maize as affected by the D × N interaction (combined data)

N levels (kg N/fad.), N \ Planting density, D	30 000 plants/fad.	25 000 plants/fad.	20 000 plants/fad.
	A	B	B
40	4.28 c	3.29 c	3.26 b
	A	B	C
80	4.60 b	3.80 b	3.57 a
	A	B	C
120	5.40 a	4.94 a	3.31 b

Table 4-d. Harvest index (HI%) of maize as affected by the D × N interaction (combined data)

N levels (kg N/fad.), N \ Planting density, D	30 000 plants/fad.	25 000 plants/fad.	20 000 plants/fad.
	A	B	C
40	45.80 a	43.00 a	42.75 a
	A	B	B
80	43.20 b	41.00 b	40.69 b
	A	B	B
120	41.23 c	40.56 b	40.13 b

Table 5. Simple correlation coefficient between maize grain yield/fad., and other variables (integrated data)

Variables	1	2	3	4	5	6	7	8	9	10	11
Y-Grain yield/fad. (ton)	0.921**	0.775**	0.785**	0.885**	0.845**	0.831**	916**	0.818**	0.911**	0.720**	0.697**
1- Ear length (cm)		0.683**	0.795**	0.840**	0.885**	0.795**	0.813**	0.671**	0.783**	0.705**	0.686**
2- Number of rows/ear			0.724**	0.694**	0.702**	0.788**	0.809**	0.614**	0.711**	0.716**	0.689**
3- Grain No./row				0.617**	0.711**	0.719**	0.801**	0.621**	0.702**	0.703**	0.683**
4- Ear weight (g)					0.851**	0.899**	0.814**	0.710**	0.689**	0.783**	0.616**
5- Grain weight/ear (g)						0.812**	0.821**	0.701**	0.691**	0.777**	0.625**
6- 100-grains weight (g)							0.887**	0.781**	0.801**	0.814**	0.709**
7- Ear yield/fad. (ton)								0.796**	0.811**	0.801**	0.727**
8- Straw yield/fad. (ton)									0.881**	0.410*	0.803**
9-Biological biomass yield/fad. (ton)										0.791**	0.819**
10- Shelling %											0.689**
11- Harvest index (HI)											-

Table 6. Partitioning of simple correlation coefficient between maize grain yield/fad., and it's attributes (combined data)

Source of variation	Value
Ear length :	
Direct effect	0.530
Indirect effect through ear weight	0.220
Indirect effect through 100-grains weight	0.171
Total (ry_1)	0.921
Ear weight :	
Direct effect	0.470
Indirect effect via 100-grains weight	0.185
Indirect effect via ear length	0.230
Total (ry_2)	0.885
100-grains weight (grain index)	
Direct effect	0.416
Indirect effect via ear length	0.195
Indirect effect via ear weight	0.220
Total (ry_3)	0.831

direction and that of grain index via ear weight detected pronounced averages in this regard, being: 0.230, 0.220 and 0.220, respectively. Ghanem (1988), Salama *et al.* (1994), Ash-Shormillesy (2005) and Moraditochaee *et al.* (2012) found similar findings in this regard.

Also, the results of Table 7 showed that ear length, ear weight, grain index and the interaction between ear length with either ear weight or with grain index were the main sources of grain yield variation, having the relative contribution of 27.05, 21.13, 18.85, 13.41 and 12.08%, respectively. It is clear that the grain yield components either alone or when were combined together produced greater direct and indirect effects on grain yield variation, being 92.52%. So, the plant breeder could focalized his selection on such components of highly contribution to the final yellow maize grain yield/fad.

At last, to maximize grain yield/fad., of the tested yellow hybrids, suitable options such as optimum plant stand and N levels must be devoted to increase ear length, ear weight and grain index as they contribute much in the final yield/fad., especially for the adopted yellow maize hybrid SC 166. Ghanem (1988), Salama *et al.* (1994) and Ash-Shormillesy (2005) obtained identical findings in this regard.

Table 7. Direct and joint effects of maize grain yield attributes as percentages contributed to final grain yield/fad., variation (integrated data)

Source of variation	C.D.	%
1. Ear length	0.2705	27.05
2. Ear weight	0.2113	21.13
3. 100-grains weight (grain index)	0.1885	18.85
4. Ear length x Ear weight	0.1341	13.41
5. Ear length x 100-grains weight	0.1208	12.08
6. Ear weight x 100-grains weight	0.0715	7.15
R^2	0.9967	-
Residual	0.0033	0.33
Total	1.0000	100.00

Both C.D. and % are symbols allude to coefficient of determination and percentage contributed, consecutively.

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تأثير كثافة الزراعة والتسميد النيتروجيني على المحصول ومساهماته لبعض أصناف الذرة الشامية الصفراء

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أقيمت هذه الدراسة خلال الموسمين ٢٠٠٩ و ٢٠١٠ بمزرعة كلية الزراعة – جامعة الزقازيق (موقع غزالة) محافظة الشرقية وذلك لدراسة استجابة ثلاثة هجن من الذرة الشامية الصفراء (هجين فردى ١٦٢، هجين فردى ١٦٦ وهجين ثلاثى ٣٥٢) لثلاثة كثافات زراعة (٣٠٠٠٠، ٢٥٠٠٠ و ٢٠٠٠٠ نبات/فدان) وثلاثة مستويات من النيتروجين (٤٠ ، ٨٠ و١٢٠ كجم ن/فدان). أظهرت النتائج وجود اختلافات صنفية معنوية فى معظم صفات المحصول ومساهماته، حيث تفوق الصنف هجين فردى ١٦٦ على نظيريه هجين فردى ١٦٢ والهجين الثلاثى ٣٥٢ فى كل من : طول الكوز، عدد الحبوب/سطر، وزن الكوز ، وزن الحبوب/كوز ، والمحصول النهائى فى وحدة المساحة من (القش – الكيزان – المحصول البيولوجى ومحصول الحبوب) ، نسبة التفريط وأخيراً دليل الحصاد. ومع ذلك، فقد تفوق الصنف هجين ثلاثى ٣٥٢ على الصنفين الآخرين فى صفة عدد السطور فى الكوز وفى دليل الحبوب. وقد ظهرت هذه الاختلافات الصنفية بوضوح فى كلا الموسمين وفى التحليل المشترك لهما. نتج عن كثافة الزراعة المنخفضة (٢٠٠٠٠ نبات/فدان) زيادة معنوية فى معظم صفات الكوز، بينما تفوقت الكثافة الأعلى وهى ٣٠٠٠٠ نبات/فدان فى زيادة المحصول النهائى /فدان من : الكيزان، القش، البيولوجى ، الحبوب ، بينما أعطت هذه الكثافة العالية قيما منخفضة فى دليل الحصاد. استجابت الهجن الثلاثة لكل زيادة فى التسميد النيتروجينى حتى ١٢٠ كجم ن/فدان، حيث تفوقت نباتات الذرة الصفراء المسمدة بالمستوى الأعلى من النيتروجين فى طول الكوز، عدد حبوب السطر، دليل الحبة وبالتالى وزن حبوب الكوز. أظهرت نتائج تداخل الفعل بين أى زوج من عوامل الدراسة فى معظم الصفات وجود زيادة معنوية فى المحصول النهائى /فدان فى حالة زراعة الصنف هجين فردى ١٦٦ بكثافة زراعة عالية ٣٠٠٠٠ نبات/فدان والتسميد النيتروجينى بالمستوى ١٢٠ كجم ن/فدان. لكن أعطى المستوى ٤٠ كجم ن/فدان زيادة جوهرية فى صفة دليل الحصاد فى ضوء استخدام مثل هذه الكثافة العالية. توضح نتائج معامل الارتباط البسيط وجود علاقة موجبة ومعنوية بين محصول الحبوب للذرة الشامية وبين جميع الصفات المحصولية تحت الدراسة. أظهرت نتائج تحليل معامل المرور : أن طول الكوز ووزنه ودليل الحبوب والتفاعل بين أى منهما كانت المصادر الأساسية لإحداث التباين الكلى فى محصول الحبوب / فدان حيث ساهمت هذه الصفات بحوالى ٩٢,٥٢% من التباين الكلى لمحصول الحبوب/فدان فى الذرة الشامية الصفراء. أخيراً، للحصول على أعلى محصول حبوب/فدان من الذرة الشامية الصفراء يفضل زراعة الصنف هجين فردى ١٦٦ تحت مستوى ٣٠٠٠٠ نبات/فدان مع التسميد النيتروجينى بالمعدل ١٢٠ كجم ن/فدان ، وأن هذه المعاملات يمكن التوصية بتطبيقها تحت ظروف منطقة الزراعة – بالزقازيق – محافظة الشرقية.