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ORIGINAL ARTICLES

Response of Some Maize Hybrids (*Zea mays* L.) to Different Levels of Nitrogenous Fertilization

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ABSTRACT

Maize hybrids response to high nitrogenous fertilization levels is a means among other means to reduce the gap between its production and consumption, from this perspective, a field nitrogen management trial using four N levels (214, 286, 357 and 429 kg N ha^{-1}) and four potentially higher yielding maize hybrids Three way cross 329 (T.W.C.329), Single cross 122 (S.C.122), Single cross 129 (S.C.129), and Single cross 10 (S.C.10) was conducted during 2011 and 2012 seasons. Results of this study indicated that all the N fertilization levels, maize hybrids and their interactions showed such significant effects on maize growth, crop yield and its components. The maximum plant height, leaf area index (LAI), chlorophyll SPAD unit, number of rows cob^{-1} , number of kernels row^{-1}, number of kernels cob^{-1}, 1000 grain weight, stover, grain, biological yields, harvest index and protein content were produced by the application either 429 or 357 kg N ha^{-1}. Among the different hybrids, (S.C. 10) showed the maximum values of all parameters which had no significant difference with T.W.C.329 in most of characteristics over other two maize hybrids (S.C.122 and S.C.129) during both cropping summer seasons. Maize hybrid S.C.129 with 429 kg N ha^{-1} during first season, and in the second season S.C.10 with 429 kg N ha^{-1} recorded the tallest cob. Also, Hybrid S.C.10 gave the maximum 1000 kernel weight with 357 kg N ha^{-1}, while the minimum weight of 1000 kernel was obtained by S.C.129 with nitrogen level 214 kg ha^{-1} during the first cropping season. Results suggested that the selected hybrids S.C.10 and 429 kg N ha^{-1} could be utilized for attaining the maximal improvement in farmer income by increasing the maize yield under the local conditions of Alexandria, Egypt.

Key words: Hybrids; nitrogen fertilizer; maize: grain yield; biological yield.

Introduction

Maize (*Zea mays* L.) is the world's widely grown highland cereal and primary staple food crop in many developing countries. It is the third most important staple food crop both in terms of area and production after wheat and rice in Egypt. Total area under cultivation of maize in Egypt is 888329 hacter which is about 25.17 % of the total cultivated agricultural land while average yield is 7.80 ton ha^{-1}. It is about 21.90 % of the total cereals production (FAO, 2011). The rapidly increasing demand of maize is driven by the increased demand for direct human consumption in the hills as a staple food crop (Ghimire *et al.,* 2007). The Egyptian government aims to decrease the gap between consumption and production *via* increasing grain yield per unit area of the agricultural land. There are several approaches to increase crop productivity, improving farming practices, employing merging technology, using modern and high yielding maize hybrids which have more efficiently for using nitrogen and more response to high rate of nitrogenous fertilizer to create more grain.

The hybrid maize gave higher yields and using N and P more efficiently than the open pollinated one at both trial locations and hybrid varieties responding up to 200 kg N ha^{-1} (Kogbe and Adediran, 2003). Also, El-Sheikh (1998) reported that application of 160 kg N ha^{-1} significantly increased grain yield of maize. On the contrary, nitrogen deficiency decreased grain yield for all hybrids, especially the older hybrids. However, there were no significant differences regarding harvest index, leaf area or plant weight at flowering stage between the N-deficient and control plants of all hybrids. Dry matter production after flowering of the nitrogen deficient plants was, significantly, lower than that of the control plants in all hybrids, also, N deficiency accelerated senescence, i.e. decreased chlorophyll and protein contents, after anthesis more for the earlier released hybrids than for the later ones (Ding *et al.*, 2005).

However, nitrogenous fertilizer is one of the most important factors for crop growth, high yield, yield components and grain quality. Where, nitrogen element plays an essential rule in many compounds essential for plant growth, chlorophyll and many enzymes. It is considered the key element in increasing crops productivity, also, helps in the use of P, K and other elements in plants.

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Additionally, Badr and Authman (2006) find out that increasing level of nitrogenous fertilization led to increase grain yield and its components. Increasing nitrogen fertilizer rate from zero up to 250 kg N ha-1 increased, significantly, the studied maize growth, yield and yield components characters where maximum number of leaves plant-1, number of cobs plant-1, number of grains cobs^{-1} , taller plants, grain and biological yield was recorded in ridge planting and application of 200 kg N ha-1 when compared with other treatments (Bakht et al., 2006). Considering soil fertility status and cropping system, the 150 kg N ha-1 application to maize variety Jalal in Peshawar was required for maximum biological and seed production (Akmal *et al*., 2010). Ears m-2, grains ear^{-1}, 10000 grain weight, grain yield, biological yield and harvest index were higher at the highest level of N (Arif *et al*., 2010). The maximum number of row per cob, number of grains per row, number of grains per cob, length of cob, cob weight, weight of grains per cob, thousand grain weights and grain yield was recorded in application of 240 kg/ha when compared with other rates and based on the results we recommend the cultivation of PR35P12 hybrid to be done with 240 kg N ha^{-1}(Delibaltova *et al.,* 2010*).* Likewise, Hammad *et al.* (2011) reported that nitrogen application, significantly, affected the maize growth, yield and related traits as maximum number of grain per cob (421), 1000 grain weight (317 g), grain yield (8.38 t ha^{-1}) harvest index (50.52%) and nitrogen use efficiency (17.81%) were observed in the plots receiving 250 kg N ha^{-1}, nonetheless application beyond this N (i.e. 300 kg ha^{-1}) enhanced biological yield (16.87 ton ha^{-1}) and seed protein contents (9.52 %). Hokmalipour and Darbandi (2011) pointed out that kernel yield and plant height were affected by nitrogen fertilizers in corn cultivars, whereas korduna cultivar had highest value of plant height in all levels of nitrogen fertilizer and maximum yield was obtained from Korduna cultivar and 180 kg N ha $^{-1}$. Wasaya (2011) reported that increasing nitrogen application rate had positive impact on growth, yield components, yield and kernel quality, where increased LAI, grains weight per cob, 1000 grain weight and grain yield was recorded with 200 kg ha^{-1} nitrogen application. Maize yield with 200 kg ha^{-1} nitrogen application was 17% and 8.50% higher than 100 and 150 kg ha^{-1} nitrogen application respectively. Nitrogen application showed positive association with protein contents.

Likewise, maize hybrids had significant effect for all the variables under study, except for plant population. For instance, hybrid Bemasal-202 out yielded at all sites by 23 to 35% than hybrid Monsanto-919. Nitrogen rates, especially affected number of grains m^{-2}, 1000-grain weight, grain yield, total dry matter and harvest index with significant differences among nitrogen rates, at 300 kg N ha^{-1}(khaliq *et al*., 2009). Maximum grain yield (7.76 ton ha^{-1}) was obtained in the plots fertilized with 240 kg N ha^{-1} for SC-404 cultivar and minimum of it (5.12 ton ha^{-1}) was obtained in the plots with 0.00 kg N ha^{-1} with SC-301 cultivar (Sharifi and Taghizadeh, 2009).

Hence, for obtaining higher maize yield and net income maize hybrid pioneer 31R88 should be grown with 200 kg ha^{-1} nitrogen application in three splits by preparing the field with chisel plough. Dawadi and Sah (2012) indicated that increasing nitrogen levels from 120 kg ha^{-1} to 200 kg ha^{-1} enhanced the plant height, grain yield and stover yield of hybrid maize whereas, increasing nitrogen levels decreased the HI and grain stover ratio. Likewise, Hoshang (2012) observed that there was significant difference among nitrogen levels regarding ear weight; whereas, the lowest ear weight was related to the lowest nitrogen level while the highest ear weight was observed by the highest nitrogen level (240 kg N ha^{-1}) while there was no significant difference among nitrogen levels on harvest index.

Khan *et al.* (2012) showed that increase of nitrogen levels enhanced final seed yield due to increase of seed number in each ear, also, nitrogen levels had, significantly, affected the maize plant height and the tallest plants were recorded under 120 and 150 kg ha^{-1} N levels and the greatest grain yield of maize (1.5 ton ha^{-1}) was found under the 160 kg ha^{-1} N level. Increasing of both qualitative and quantitative yield and some agronomic characteristics such as plant height, cob length and diameter should be applied 225 Kg N ha^{-1} (Nemati and Sharifi, 2012).Also, Sharifai *et al.* (2012) indicated that the effect of nitrogen on such yield components as cob diameter, cob length and 100 grain weight was significant as the response was in the range of 80 to 120 kg ha^{-1}. Likewise, Moraditochaee *et al.* (2012) showed that the effect of nitrogen fertilizer on grain yield, straw yield, harvest index, plant height, number of ear per plant, 1000 grain weight and ear length were significant but on number of rows ear^{-1} was no significant. Between nitrogen treatments, use of 200 kg ha^{-1} pure nitrogen resulted highest grain yield with 10.53 ton ha^{-1}.

The objectives of the present study were to evaluate the response of modern maize hybrids to nitrogenous fertilization levels on growth, yield, and yield components, and to determine the superior hybrids for growth and grain yield of maize under each level of nitrogenous fertilization.

Materails and Methods

Two field experiments were conducted in the experimental farm of the Faculty of Agriculture (Saba Basha), Alexandria University, during the summer growing seasons of 2011 and 2012 to study response of four maize hybrids to four levels of nitrogenous fertilizer in form of Urea (46.5%N) on the growth, grain yield and yield components. The soil type of experimental site was clay loamy. The mechanical and chemical analyses of the experimental site are presented in Table (1). The preceding crop was Egyptian clover (*Trifolium alexanderinum*, L.) during both seasons of the study. The experimental design was split plot with three replicates and the treatments were distributed at random as follow: Four nitrogen fertilizer levels (214, 214, 357 and 460 kg N ha^{-1}) were randomized within each main plots**.** Sub plots contained four maize hybrids which were; Three way cross 329 (T.W.C.329), Single cross 122 (S.C.122), Single cross 129 (S.C.129), and Single cross 10 (S.C.10). The size of each subplots was (3X3.5) =10.5 m^2 including 5 ridges, 3 m long and 60 cm apart, The two sowing dates were 30th and 20th of May for 2011 and 2012 seasons, respectively. Application of phosphorus fertilizer was in the form of calcium super phosphate (15.5% P_2O_5) was applied in one dose at sowing and nitrogen fertilizer in the farm of Urea (46.5%N) was applied in two splits. All other cultural practices such thinning, hoeing and plant protection measures were kept normal for the crop at all sites.

Agronomic attributes were characterized as plant height and leaf area indexes (LAI) were recorded. Leaf area was measured according to the method described by Radford (1967) according to the equation, LA = K (L x B), where: LA= leaf area (cm^2), K= constant (0.75), L= leaf length (cm), B = maximum leaf width (cm) and LAI= LA/GA; where GA= ground area which occupied by plant. The Chlorophyll SPAD unit pigments were measured by direct digital reading on chlorophyll meter SPAD-502, where the value measured by the chlorophyll present in the plant leaf. The values are calculated based on the amount of light transmitted by the leaf in two wave length regions in which the absorbance of chlorophyll is different. Yield and yield components as cob length (cm), number of rows cob^{-1}, number of kernels row^{-1}, number of kernels cob^{-1},100 kernels weight (g), stover yield Mg ha^{-1}, grain yield Mg ha^{-1}, biological yield Mg ha^{-1}, harvest index (H.I., %) are measurements were obtained as an average of ten ears random from each plot.

Data were, statistically, analyzed as split-split plot design according to Gomez and Gomez (1984), using the split- split model as obtained by CoStat (1998-2005). Treatment' means were compared according to Fisher test at ($p>0.05$) least significant difference (LSD) to estimate the significant differences among treatments (Duncan's, 1955).

Table 1: Physical and chemical properties of the experimental soil sites during the two cropping seasons.

Seasons	Physical properties:				Chemical properties				Available cations meq/100 g soil			
	Clay	Silt	Sand	Soil texture	PH	$E.C_e$ (dS/m)	Total C %	Total N %	Ca^{++}	Mg^{++}	Na^+	K^+
2011	41.4	48.6	14.1	Clay loam	8.53	2.55	4.52	0.38	26.33	16.30	3.94	1.49
2012	42.4	49.3	14.2	Clay loam	8.36	2.54	4.63	0.35	25.36	15.88	3.85	1.56

Results and Discussions

Significant effect of nitrogenous fertilization levels effect on plant height presented (Table 2). However, Plant height increased in the range of nitrogen levels from 214 to 429 kg N ha^{-1} during both seasons. Nitrogen fertilization levels, significantly, increased the LAI In general, the maximum mean values of LAI (3.72 and 4.37) were recorded due to the highest N- level (429 kg N ha^{-1}), while the minimum mean values of LAI (3.15 and 3.10) were obtained with the lowest level of nitrogen 214 kg N ha^{-1} , each in turn during the two cropping seasons. By comparing the effect of various applied nitrogen levels on chlorophyll disclosed that maximum increase of parameter under investigation was produced using N- fertilization of 429 kg N ha^{-1} and minimum increase in chlorophyll were produced using 214 kg N ha^{-1}. With regard to the effect of nitrogen levels on cob length, the obtained results disclosed that maximum cob length was produced upon applying 429 kg N ha^{-1} as compared to other levels. While, the comparison of different nitrogen fertilization levels on number of rows per cob showed that maximum number of rows cob^{-1} was found by the application of 429 kg N ha^{-1}. Respecting the effect of nitrogen levels on number of kernels row^{-1}, the tabulated results revealed that maximum number of kernels row^{-1} was produced due to applying 429 kg N ha^{-1} as compared to other levels (Table 2). While, number of kernels cob^{-1} was increased by increasing nitrogen fertilization levels up to 429 kg N ha^{-1}. While, applying 429 kg N ha^{-1} also produced, significantly, the maximum mean values of 1000 grain weight and minimum 1000 kernel weight which produced by applying 214 kg N ha^{-1}.

The differences in grain weight could be due to different nitrogen application levels which could be attributed to variation in the response of maize hybrids' nutrition. While, the level of 429 kg N ha^{-1} produced, significantly, the maximum stover yield, meanwhile, the minimum stover yield was produced due to applying 214 kg N ha^{-1}. The response of different nitrogen levels to grain yield was also found highly significant. The grain yield is a function of combined effect of all the individual yield components. In the case of N level 429 kg N ha^{-1} produced, significantly, higher grain yield, while the minimum grain yield was produced due to the fertilization with 214 kg N ha^{-1}.

It is clear that grain yield increased with increasing nitrogen levels. While, using 429 kg N ha^{-1} produced, significantly, the maximum biological yield and the minimum biological yield was produced due to applying

214 kg N ha^{-1}. Harvest index showed that the potential physiological efficiency of plants to convert the fraction of photoassimilation rates to high grain yield. Similarly, the harvest index of maize showed the significant effect of different application levels of N on various hybrids (Table 3). For instance, fertilizing the maize with 429 kg N ha^{-1} produced the maximum harvest index. Significantly, the minimum harvest index was produced due to application 214 kg N ha^{-1} (Table 3).

These results were similar, more or less, with the findings of Ding *et al.* (2005), Onasanya *et al.* (2009); khaliq *et al*. (2009); Sharifi and Taghizadeh, 2009; Akmal *et al.* (2010); Hammad *et al*., (2011); Wasaya, (2011); Dawadi and Sah, (2012); Khan *et al*., (2012); Nemati and Sharifi, (2012), and Sharifai *et al.,* (2012) ; Moraditochaee *et al.,* (2012).

Maize hybrids expressed significant difference, whereas the maize hybrid 'S.C.10' gave the tallest plant as compared with other hybrids during both cropping seasons, i.e. 2011 and 2012. The comparison of treatments' means indicated that the maize hybrid 'S.C.10' produced, significantly, the maximum height as compared to other hybrids used in the present study (Table 2). Concerning the chlorophyll SPAD unit pointed out that maize cultivars 'T.W.C. 329' and 'S.C.10' had significantly higher chlorophyll. While, the minimum mean value of chlorophyll was recorded by 'S.C. 129' (Table 2).

The finding regarding the cob length of maize as affected by maize hybrids reported that 'S.C.10' produced the maximum length followed by 'T.W.C329' with no difference, while the minimum cob length was produced by 'S.C. 122' with no difference with 'S.C.129' (Table 2). In the case of number of rows cob^{-1} 'S.C.10' gave significantly higher number of rows cob^{-1} followed by 'T.W.C. 329', 'S.C. 122' and 'S.C. 129' (Table 2). The finding regarding the number of kernels row^{-1} as affected by maize hybrids and N levels showed that the hybrid 'S.C.10' produced the maximum number of the given trait with no difference with 'T.W.C. 329' while 'S.C. 122' hybrid registered the minimum number. Similarly, in the case of number of kernels cob^{-1}, the 'S.C.10' gave, significantly, higher number of kernels cob^{-1} followed by 'T.W.C. 329', 'S.C. 122' and 'S.C. 129' (Table 2).

Table 2: Means of plant height (cm), leaf area index (L.A.I), chlorophyll SPAD unit, cob length (cm), number of row cob^{-1}, and number of kernels row^{-1} of the four new hybrids of maize as affected by nitrogen fertilization levels during the both seasons of 2011 and 2012.

Treatments	Plant height (cm)		L.A.I		Chlorophyll SPAD unit		Cob length(cm)		Number of rows cob^{-1}		Number of kernels row^{-1}	
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
Nitrogen fertilization levels (N)												
214 Kg N ha^{-1}	266.50	264.08	3.04	3.10	33.64	30.26	17.77	18.10	12.90	13.30	37.03	37.15
286 Kg N ha^{-1}	278.00	275.17	3.43	3.32	32.63	29.04	17.85	16.93	12.73	13.70	40.43	34.95
357 Kg N ha^{-1}	277.25	275.50	3.21	3.42	35.44	31.94	18.72	17.88	13.27	13.53	41.47	39.63
429 Kg N ha^{-1}	288.75	286.17	4.17	4.37	37.92	34.35	20.15	19.21	13.67	13.77	41.63	40.41
L.S.D$_{0.05}$	8.728	7.67	0.391	0.346	3.462	3.596	0.794	1.203	0.460	0.682	2.884	2.503
Maize hybrids (H)												
T.W.C. 329	268.17	264.92	3.15	3.23	38.83	35.33	18.98	18.55	13.57	14.40	40.58	38.30
S.C. 122	277.25	276.17	3.47	3.58	33.29	29.46	18.05	17.35	12.57	12.90	38.70	36.32
S.C. 129	274.75	271.33b	3.51	3.67	32.03	28.46	18.38	17.44	13.03	12.93	40.10	36.98
S.C.10	290.33	288.50	3.72	3.73	35.48	31.95	19.07	18.78	13.40	14.07	41.18	40.55
L.S.D$_{0.05}$	9.982	8.632	0.370	0.340	4.269	4.245	0.707	1.083	0.650	0.694	1.734	3.043
Interactions (x)												
L.S.D$_{0.05}$ N x H	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	1.414	2.167	N.S.	N.S.	N.S.	N.S.

Table 3: Means of number of kernels cob^{-1} , Kernel weight cob^{-1}, 100 kernel weight (g), Stover yield Mg ha^{-1}, Grain yield Mg ha^{-1}, biological yield Mg ha^{-1}, and harvest index (%) of the four new hybrids of maize as affected by nitrogen fertilization levels during the both seasons of 2011 and 2012.

Treatments	Number of kernels cob^{-1}		100 kernel weight (g)		Stover yield Mg ha^{-1}		Grain yield Mg ha^{-1}		Biological yield Mg ha^{-1}		Harvest index (%)	
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
Nitrogen fertilization levels (N)												
214 Kg N ha^{-1}	478.83c	495.81	30.74	34.04	9.35	7.27	6.21	4.89	15.55	12.16	39.75	40.02
286 Kg N ha^{-1}	515.51	479.67	30.53	39.55	9.24	7.19	6.62	5.11	15.86	12.30	41.73	41.55
357 Kg N ha^{-1}	551.07	537.15	33.35	40.44	9.64	7.50	6.62	5.13	16.26	12.63	40.85	40.76
429 Kg N ha^{-1}	568.95	558.41	36.57	41.07	9.96	7.83	7.29	5.67	17.22	13.50	42.36	42.15
L.S.D$_{0.05}$	48.498	41.519	4.007	3.929	0.459	0.334	0.269	0.146	0.697	0.449	1.007	0.809
Maize hybrids (H)												
T.W.C. 329	550.91	541.00	32.42	36.42	10.01	7.79	7.05	5.51	17.07	13.30	41.49	41.58
S.C. 122	486.69	468.07	31.97	38.05	8.85	6.88	6.34	4.89	15.19	11.78	41.73	41.55
S.C. 129	523.50	477.62	31.88	40.01	8.93	6.94	6.20	4.81	15.13	11.75	40.90	40.82
S.C.10	553.27	584.35	34.93	40.62	10.41	8.18	7.12	5.58	17.50	13.76	40.57	40.54
L.S.D$_{0.05}$	37.802	52.973	2.343	3.046	0.9771	0.784	0.587	0.484	1.293	1.027	2.635	2.883
Interactions (x)												
L.S.D$_{0.05}$ N x H	N.S.	N.S.	4.687	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

In the same context, the trait of 1000 kernel weight which is an important yield contributing parameter (Table 3), showed the maximum increase in the hybrid 'S.C.10' with respect to other hybrids. With regard to stover, the grain and biological yields showed the maximum increase in 'S.C.10' and 'T.W.C.329' hybrids with respect to other hybrids (Table 3). However, there was no significant difference among maize hybrids on harvest index (Table 3). Whereas, the genetic potential of maize is determined by hybrid, agro ecological and climatic conditions as well as by the technology of growing (Epinal *et al.*, 2001; Delibaltova *et al*., 2009; Mohamed *et al*., 2008; Zheliazkov, 2007).These results are matching with those of Kogbe and Adediran (2003); Ding *et al.* (2005), Sharifi and Taghizadeh (2009); Arif *et al.* (2010); Delibaltova *et al.* (2010) and Hokmalipour and Darbandi (2011).

The interaction between hybrids and nitrogenous levels was found to be not significant on L.A.I. and chlorophyll (Table 2). While, Maize hybrid 'S.C.129' with 429 kg N ha^{-1} , the highest values of cob length during first season presented in (Figure 1), and in the second season the hybrid 'S.C.10' fertilized with 429 kg N ha^{-1} , recorded the tallest cob as shown in (Figure 2). The interaction between the maize hybrids and N levels on number of rows per cob and number of kernels row^{-1} had not significant differences (Table 2).

Interaction between maize hybrids and nitrogen fertilization levels affecting 1000 grain weight was found to be, significant, where the hybrid 'S.C.10' gave the maximum mean value of 1000 kernel weight with 357 kg N ha^{-1}, while the minimum weight of 1000 kernel was obtained with the hybrid 'S.C.129' at nitrogen level of 214 kg ha^{-1} during the first cropping season (Figure 3). While, the interaction between maize hybrids and nitrogen fertilization levels affecting stover, grain, biological yields and harvest index % was found no significant (Table 3). These results are in cope with the findings of Ding *et al.* (2005); Khaliq *et al.* (2009); Sharifi and Taghizadeh.2009; Akmal *et al*. (2010); Wasaya (2011).

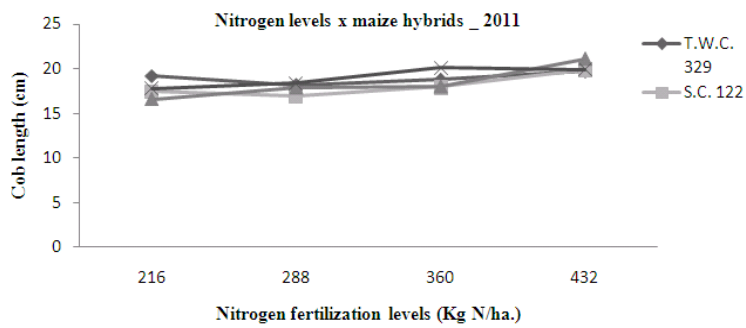

Fig. 1: Effect of interaction between nitrogen fertilization and maize hybrids on cob length (cm) during season 2011.

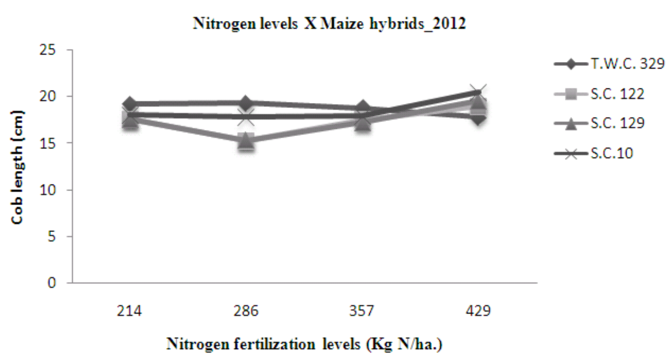

Fig. 2: Effect of interaction between nitrogen fertilization and maize hybrids on cob length (cm) during season 2012.

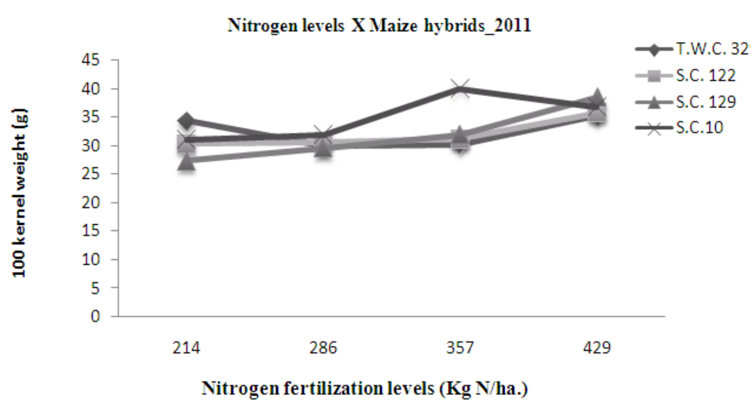

Fig. 3: Effect of interaction between nitrogen fertilization and maize hybrids on 100 kernel weight (g) during season 2011.

Conclusions:

Considering all the results presented above, it can be concluded that, application of 357 kg N ha^{-1} to the maize hybrid 'S.C.10' is an optimal for obtaining higher grain yield of maize under the agro-metrological conditions of Alexandria, Egypt. In addition, we recommend that this dose (357 kg N ha^{-1}) of nitrogen can be applied to the hybrid 'T.W.C.329' in other regions for attaining the optimum yield of maize. Further, it is concluded that more hybrids of maize can be tested for the same dose of nitrogen for improving the grain yield of maize. Lastly, we recommend that farm extension services should disseminate this work to farmers so that they can increase their farm income by getting the optimum yield of maize.

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