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Response of Two Yellow Maize Hybrids to Irrigation Intervals and Nitrogen Fertilizer Levels

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ABSTRACT

In order to study the response of two yellow maize hybrids i.e. SC 173 and TWC 352 to three irrigation intervals i.e. 12, 16 and 20 days and four nitrogen fertilizer levels i.e. 0, 45, 90 and 135 kg N/fad. The present investigation was carried out during two successive seasons of summer 2011 and 2012 at the Agriculture Research Station, Faculty of Agric., Zagazig Univ., Ghazala Location, Sharkia Governorate, Egypt. The combined analysis indicated that all growth characters as well as grain yield and its attributes except number of rows/ear and shelling percentage were significantly decreased when irrigation interval was prolonged from 12 or 16 days to 20 days. It was found that SC 173 surpassed TWC 352 in all growth characters, grain yield and its attributes except, number of ears/ plant, number of rows/ear and shelling percentage. On the other direction, TWC 352 surpassed SC 173 in ear diameter. Respecting to the influence of nitrogen fertilizer levels, the results indicated that ear length, ear diameter, 100-kernel weight, kernel weight/ear and grain yield/fad were significantly increased with each increase in nitrogen fertilizer level up to 135 kg N/fad. Whereas, plant height, chlorophyll content and number of kernels/row were significantly increased by raising nitrogen fertilizer level up to 90 kg N/fad while, number of ears/plant was responded only up to application of 45 kg N/fad. The results of interaction between the studied factors recorded significant increase in kernel weight/ear and grain yield/fad due to increasing nitrogen fertilizer level up to 135 kg N/fad under irrigation intervals of 12 or 16 days. In addition, SC 173 presented good response for N fertilizer up to 135 kg than TWC 352 in 100-kernel weight, kernel weight/ear and grain yield/fad. It could be recommended that irrigation of SC 173 hybrid at 16 days intervals with adding 135 kg N/fad maximized grain yield per unit area under clay soil condition of Sharkia Governorate, Egypt.
Keywords: Irrigation intervals, Maize hybrids, Nitrogen fertilizer levels.

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important grain crops grown principally during the summer season in Egypt. It is the highest yielding grain crop having multiple uses such as food for human, feed and fodder for poultry and livestock. The total cultivated area of maize in Egypt reached about 2.47 million fads., produced around 8.06 million tons in 2014 season, this production is not sufficient to meet the continuous increase of consumption where about 5.77 million tons were imported (FAO, 2016). This in turn necessitates more extension in the maize cultivated area with high yielding hybrids as well as optimizing the needs of irrigation water.

Several reports recorded significant reduction in maize grain yield and its attributes due to prolonging the irrigation interval or water deficit (Ibrahim and Kandil, 2007; El-Hendawy *et al*., 2008; El-Metwally *et al*., 2009; Ahmed *et al*., 2011; El-Shahed *et al*.,2013; Alfalahi *et al*.,2015 and Gomaa *et al*., 2015). However, El-Sobky *et al*. (2014) reported no significant differences in yield and yield attributes of maize due to prolonging irrigation interval from 14 to 18 days.

It is well known that maize genotypes differ in their yielding abilities depending on the genetic potential and its interaction with the environmental conditions. Many investigators reported significant differences among the tested cultivars in grain yield and its attributes (Oraby *et al*., 2003; Abd El-Maksoud and Sarhan, 2008 Ahmed *et al*., 2011; Abdou *et al*., 2012; El-Shahed *et al*., 2013; Ibrahim *et al*., 2014 and Nassr *et al*., 2015).

Maize is one of the high demands nitrogen crops (Dharmakeerthi and Kay, 2013). But using high nitrogen rates lead to damage the environment through leaching to groundwater (Liu *et al*., 2013). Therefore, the optimum nitrogen rate needs to be determined for achieving greatest increment in maize yield and potential environmental benefits (Wang and Xing, 2016).

Nitrogen is an important component in many biological compounds that plays a major role in photosynthetic activity, protein synthesis and crop yield capacity (Hirel *et al*., 2005). Nitrogen is the key input for achieving higher maize grain yield. In this connection, Attia *et al*. (2013) and El-Sobky *et al*. (2014) reported that increasing nitrogen fertilizer levels up to 120 kg N/fad caused significant increase in maize grain yield and its attributes. Moreover, Ahmed and El-Sheikh (2002) and Abd El-Maksoud and Sarhan (2008) found that maize grain yield and its attributes showed significant response to raising nitrogen fertilizer levels up to140 kg N/fad. Furthermore, Nassr *et al*. (2015) found that, raising N-fertilizer level up to 150 kg N/fad was associated with significant increase in maize grain yield and its attributes.

Therefore, the main purpose of this investigation was aimed to study the effect of irrigation intervals and nitrogen fertilizer levels on yield and its attributes of two yellow maize hybrids.

MATERIALS AND METHODS

These experimental works were performed for two consecutive summer seasons of 2011 and 2012 at the Agricultural Research Station, (Ghazala Location), Faculty of Agriculture, Zagazig University, Sharkia Governorate, Egypt. The ultimate aim of this investigation was to study the influence of nitrogen fertilizer levels (0, 45, 90 and 135 kg N/fad) and irrigation intervals (12, 16 and 20 days) on growth, yield and its attributes of two yellow maize hybrids (SC 173 and TWC 352). The experiment was laid out in strip-split plot design of three replications. Horizontal strips were allocated to irrigation interval treatments and the vertical strips were allocated for maize hybrids whereas, nitrogen fertilizer levels were distributed in sub plots. In order to prevent the lateral seepage of water, main plots were surrounded by ditches and canals with distance of 1.5 m. Date and number of irrigations in each irrigation intervals are presented in Table 1.

Table 1. Date and number of irrigations in each irrigation interval treatment

Irrigation intervals	Date of irrigation									
	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	total
12 days	Planting	21	33	45	57	69	81	93	105	9
16 days	Planting	21	37	53	69	85	101	×	×	7
20 days	Planting	21	41	61	81	101	×	×	×	6

The net plot area was 14 m^2 which included 5 ridges 4 m in length andn70 cm apart. The soil of the experimental site was clay in texture where it has a particle size distribution of 59.9, 24.6 and 15.5 for clay, silt and sand, respectively. The soil had an average pH of 8.1 and organic matter content of 0.67%. The average available N, P and K contents were 21.3, 24.0 and 147.0 ppm, respectively (Source: Central Laboratory, Faculty of Agriculture, Zagazig University, Zagazig, Egypt). The preceding winter crop was wheat in both seasons. The two tested cultivars were planted on 21st and 26th May in the first and second seasons, respectively. Maize grains were hand sown in hills 25 cm apart using dry sowing method on one side of the ridge. Plants were thinned to one plant per hill before the first irrigation (21 days after planting). The irrigation interval treatments started from the 2nd irrigation. Phosphorus at level of 15.5 kg P_2O_5/fad., as ordinary super phosphate (15.5% P_2O_5) was band placed at the time of planting, potassium fertilizer at the rate of 24 kg K_2O/fad, in the form of potassium sulphate (48% K_2O) was applied with the first N fertilizer dose while, nitrogen fertilizer levels in form of ammonium nitrate (33.5% N) at above mentioned rates was added at two equal doses, the first one after thinning and the second was added just before the second irrigation. All other agricultural practices, except the studied factors, were manually performed as recommended during growth seasons. Harvesting was practiced on 21st and 26th September in both seasons, respectively.

At heading, five ear-bearing leaves plants from the fourth ridge were used to determine growth characters i.e., plant height, ear leaf area (was measured according to Saxena and singh (1965) by using blade length × maximum blade width × 0.75) and total chlorophyll content (SPAD) of ear leaf which measured using chlorophyll meter according to Castelli *et al.* (1996). At harvest, five plants sample were harvested at random from the fourth ridge in each plot of the three replicates. Thereto, the following respects were set up: ear length (cm), ear diameter (cm), number of rows/ear, number of kernels/row, kernel weight/ear (g) and shelling percentage. Thereafter, a bulk sample including all plants in the two central ridges was harvested manually to determine: number of ears/plant, 100-kernel weight (g) and kernel yield (ton/fad.). Kernel yield was adjusted to a constant moister content of 15%.

All the experimental data of both seasons and their combined were subjected to the Analysis of Variance according to the standard statistical procedures described by Gomez and Gomez (1984) by using MSTAT-C (1989) where statistical program version 2.1 was used. The statistical significant means were separated by means of Duncan's Multiple Range Test at 0.05 and 0.01 levels of probability (Duncan, 1955). The combined analysis of variance of both trials was calculated after establishing by Bart lett's Homogeneity Test, since the error variance of the individual seasons was homogeneous. In interaction Tables, capital and small letters were used to compare both rows and columns means, successively. *, ** and N.S. are symbols in all listed Tables of this study, referring to the significant and highly significant differences between means at 5 and 1% levels of probability and insignificant distinctions, orderly. The response of grain yield to nitrogen fertilization was calculated by SPSS v.16.0 (IBM Corp., Armonk, NY, USA). Maximum detected nitrogen level (X_{max}) and yield (Y_{max}) were calculated according to Snedecor and Cochran (1967).

RESULTS AND DISCUSSION

A- Effect of irrigation intervals:

Results presented in Table 2 clear that irrigation treatments of either 12 or 16 days intervals significantly increased all the growth studied traits in both seasons and their combined, i.e. plant height, ear leaf area (ELA) and chlorophyll content (SPAD value) as compared with those obtained by using 20 days interval. These results stated the great influence role of water on growth of plants, since nutrient uptake is closely linked to water soil status whereas the decline in available water moisture might decrease the diffusion rate of nutrient from soils matrix to roots (Sobhkhizi *et al.*, 2014). The depression in maize growth parameters, as results of water deficits may be attributed to the loss of turgor pressure which affects the rate of cell division and enlargement. (Ghooshchi *et al.*, 2008). In addition, the obtained results are in accordance with those reported by Ibrahim and Kandil (2007), El-Shahed *et al.* (2013) and Gomaa *et al.* (2015). However, El-Sobky *et al.* (2014) reported that no significant differences were noticed in maize plant height due to prolonging irrigation interval from 14 to 18 days.

Results pertaining to the influence of irrigation interval, varital differences and nitrogen fertilizer levels on number of ears/plant, ear length and diameter, number of rows/ear, number of kernels/row, 100-kernel weight, kernel weight/ear, shelling percentage and grain yield/fad are presented in Tables 3, 4 and 5. In both seasons and their combined analysis, irrigation intervals significantly affected all the aforementioned traits, except number of rows/ear (in the first season and the combined analysis) as well as shelling percentage. Irrigation maize fields every either 12 or 16 days caused significant increment in these characters as compared with fields irrigated every 20 days. In other words, prolonging irrigation interval from 12 or 16 to 20 days significantly reduced grain yield and its attributes as could be seen in Tables 3, 4 and 5, with the exception of number of rows/ear in the first season and the combined analysis and shelling percentage during both seasons and their combined analysis which did not show any significant response to irrigation intervals. The obtained results exhibited no significant differences between 12 and 16 days irrigation intervals in grain yield and its attributes, meaning that maize field can be irrigated every 16 days without any significant decrease in grain yield and its attributes. Therefore, the total number of irrigations is seven only instead of nine i.e. saving two irrigations without any significant reduction in maize grain yield or its attributes. The reduction of grain yield and its attributes as affected by irrigation every 20 days may be occurred due to the deficient amount of available water which is held by soil, so tenaciously, the plant must expand extra energy to obtain it. Under these conditions, the rate of intake by plant is not sufficient enough to maintain turgidity of leaves, the dry yield per unit of consumed decreased. The reduction of grain yield and its attributes under water stress may be also due to the unbalanced soil water-air under these conditions, which lead to reduction in photosynthesis activity as well as the adverse relations between hormones and biological processes in whole plant organs (Ibrahim and Kandil, 2007).

Table 2. Means of plant height (cm), ear leaf area (dm^2), and chlorophyll content (SPAD) of the two maize hybrids as affected by irrigation intervals and nitrogen fertilizer level during two successive summer seasons (2011 and 2012) as well as their combined

Main effects and interactions	Plant height (cm)			Ear leaf area (dm^2)			Chlorophyll content (SPAD)		
	2011	2012	Comb.	2011	2012	Comb.	2011	2012	Comb.
Irrigation intervals(I):									
12 days	249.6 a	244.0 a	246.8 a	61 a	59 a	60 a	52.12 a	48.38 a	50.25 a
16 days	248.5 a	250.9 a	249.7 a	62 a	58 a	60 a	49.18 a	46.34 a	47.76 a
20 days	225.8 b	205.2 b	215.5 b	56 b	52 b	54 b	44.52 b	40.86 b	42.69 b
F-test	**	**	**	**	*	**	*	*	**
Hybrids (H):									
S.C.173	253.4	248.3	250.9	62	58	60	50.24	46.42	48.33
T.W.C. 352	229.1	218.4	223.7	57	55	56	46.97	43.96	45.46
F-test	**	**	**	*	N.S	*	**	N.S	**
Nitrogen fertilizer levels (N):									
0.0 KgN/fad. (control)	226.3 b	208.9 c	217.6 b	55 d	49 c	52 d	41.82 c	40.50 c	41.16 c
45.0 KgN/fad.	237.5 ab	228.8 b	233.1 ab	59 c	54 b	57 c	47.39 b	44.18 b	45.79 b
90.0 KgN/fad.	247.9 a	246.4 a	247.2 a	61 b	60 a	60 b	52.06 a	47.94 a	50.00 a
135.0 KgN/fad.	253.3 a	249.2 a	251.3 a	64 a	62 a	63 a	53.18 a	48.14 a	50.66 a
F-test	**	**	**	**	*	**	**	**	**
Interactions:									
I x H	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
I x N	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
H x N	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

Table 3. Means of number of ears/plant, ear length (cm) and ear diameter (cm) of the two maize hybrids as affected by irrigation intervals and nitrogen fertilizer level during two successive summer seasons (2011 and 2012) as well as their combined

Main effects and interactions	Number of ears/plant			Ear length (cm)			Ear diameter (cm)		
	2011	2012	Comb.	2011	2012	Comb.	2011	2012	Comb.
Irrigation intervals(I):									
12 days	1.06 a	1.03 a	1.05 a	19.5 a	18.0 a	18.7 a	4.2 a	4.0 a	4.1 a
16 days	1.04 a	1.04 a	1.04 a	19.4 a	18.6 a	19.0 a	4.3 a	4.0 a	4.2 a
20 days	0.96 b	0.98 b	0.97 b	17.2 b	15.7 b	16.5 b	3.8 b	3.4 b	3.6 b
F-test	*	*	**	*	*	*	**	*	**
Hybrids (H):									
S.C.173	1.00	1.02	1.01	20.1	18.9	19.5	4.0	3.7	3.9
T.W.C. 352	1.04	1.02	1.03	17.2	16.0	16.6	4.2	3.9	4.0
F-test	NS	NS	NS	*	*	**	*	*	*
Nitrogen fertilizer levels(N):									
0.0 KgN/fad. (control)	0.92 b	0.96 b	0.94 b	15.4 d	14.3 c	14.9 d	3.6 d	3.4 c	3.5 d
45.0 KgN/fad.	1.03 a	1.02 a	1.03 a	17.8 c	16.5 b	17.1 c	3.9 c	3.7 b	3.8 c
90.0 KgN/fad.	1.06 a	1.03 a	1.05 a	19.8 b	19.0 a	19.4 b	4.3 b	4.0 a	4.1 b
135.0 KgN/fad.	1.05 a	1.04 a	1.05 a	21.7 a	19.9 a	20.8 a	4.6 a	4.1 a	4.3 a
F-test	*	*	**	**	*	**	**	*	**
Interactions:									
I x H	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
I x N	N.S	*	*	N.S	N.S	N.S	N.S	N.S	N.S
H x N	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

***,** and NS indicate significance at 0.05 and 0.01 levels and insignificancy of differences, in respective order.**

In addition, drought disturbs the series of development processes such as growth, organ development, flower production, pollination, grain formation and then grain filling in maize crop (Aslam *et al*., 2013). Furthermore, prevailing drought reduces plant growth and development, leading to hampered flower production and grain filling and thus smaller and fewer grains. A reduction in grain filling occurs due to a reduction in the assimilate partitioning and activities of sucrose and starch synthesis enzymes (Anjum *et al*., 2011). The reduction in grain yield and its attributes due to prolonging irrigation intervals was also reported by many investigators, of them El-Hendawy *et al*. (2008), Alfalahi *et al*. (2015) and Gomaa *et al*. (2015). However, El-Sobky *et al*. (2014) indicated that no significant differences were observed in yield and yield attributes of maize due to prolonging irrigation interval from 14 to 18 days under clay soil conditions.

B- Maize hybrids performance:

The two tested maize hybrids varied significantly in all studied growth traits (Table 2), where SC 173 surpassed TWC 352 in plant height in both growing seasons and their combined analysis, as well as ear leaf area and chlorophyll content of ear leaf (SPAD) during first season and combined analysis, while the differences between the two tested cultivars did not reach the level of significant in the second season. The differences between the two studied hybrids in growth characters may be due to their genetic make-up and their interactions with the environmental conditions. Such differences in growth among maize hybrids were also reported by Abd El-Maksoud and Sarhan (2008). In addition, El-Shahed *et al*. (2013) reported that, S.C. 173 surpassed T.W.C. 352 in plant height and chlorophyll content.

The differences between the two tested hybrids in grain yield and its attributes presented in Tables 3, 4 and 5. The tabulated results exhibited that SC 173 outyeilded TWC 352 in ear length, number of kernels/row, 100-kernal weight, kernel weight/ear and grain yields/fad, in both seasons and their combined analysis. Furthermore, SC 173 surpassed the other tested hybrid in shelling percentage during the 2nd season only while the results of the first season confirmed by those of the combined showed no significant differences between the two tested hybrids in this respect. On the other hand, TWC 352 surpassed the other one in ear diameter. Moreover, number of ears/plant and number of rows/ear did not vary significantly respecting the two tested hybrids. This was the case during both seasons and their combined analysis. The differences between the two studied hybrids in grain yield and its attributes recorded in Tables 3, 4 and 5 may be due to their genetic make-up and their interactions with the environmental conditions. The superiority of SC 173 in grain yield could be attributed to its superiority in growth traits (Table 2) and most yield attributes (Tables 3, 4 and 5). The differences among maize hybrids in grain yield and its attributes were also reported by Oraby *et al*. (2003), Abd El-Maksoud and Sarhan (2008) and Nassr *et al*. (2015). In addition, El-Shahed *et al*. (2013) reported that, S.C. 173 surpassed T.W.C. 352 in ear length, number of kernels/row and grain yield/fad, while, T.W.C. 352 surpassed S.C. 173 in number of rows/ear and 100-kernel weight. Furthermore, Ibrahim *et al*. (2014) indicated that, S.C. watania-4 surpassed significantly T.W.C. 310 in ear length, ear diameter, number of rows/ear, grain weight/ear, 100-grain weight and grain yield/fad.

Table 4. Means of number of rows/ear, number of kernels/row and 100-kernel weight (g) of the two maize hybrids as affected by irrigation intervals and nitrogen fertilizer level during two successive summer seasons (2011 and 2012) as well as their combined

Main effects and interactions	Number of rows/ear			Number of kernels/row			100-kernel weight (g)		
	2011	2012	Comb.	2011	2012	Comb.	2011	2012	Comb.
Irrigation intervals(I):									
12 days	13.8	13.6 a	13.7	41.3 a	39.4 a	40.4 a	38.37 a	35.08 a	36.73 a
16 days	13.8	13.5 a	13.6	39.9 a	39.1 a	39.5 a	37.75 a	35.92 a	36.84 a
20 days	13.5	12.5 b	13.0	34.8 b	34.8 b	34.8 b	33.71 b	30.71 b	32.21 b
F-test	N.S	*	N.S	*	*	**	*	**	**
Hybrids (H):									
S.C.173	13.7	13.2	13.4	40.9	41.5	41.2	38.28	35.00	36.64
T.W.C. 352	13.7	13.2	13.5	36.4	34.0	35.2	34.94	32.81	33.88
F-test	N.S	N.S	N.S	*	**	**	**	*	**
Nitrogen fertilizer levels (N):									
0.0 Kg N/fad. (control)	13.3 b	13.1	13.2	34.0 c	33.3 b	33.7 c	32.83 d	29.44 c	31.14 d
45.0 Kg N/fad.	13.5 b	13.0	13.3	37.7 b	34.6 b	36.2 b	35.72 c	32.50 b	34.11 c
90.0 Kg N/fad.	14.1 a	13.2	13.7	41.0 a	41.3 a	41.2 a	37.72 b	35.91 a	36.82 b
135.0 Kg N/fad.	14.0 a	13.4	13.7	41.9 a	41.8 a	41.9 a	40.17 a	37.76 a	38.97 a
F-test	*	N.S	N.S	**	**	**	**	**	**
Interactions:									
I x H	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
I x N	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
H x N	N.S	N.S	N.S	N.S	N.S	N.S	*	*	**

***,** and NS indicate significance at 0.05 and 0.01 levels and insignificancy of differences, in respective order.**

C- Effect of nitrogen fertilizer levels:

All growth characters presented in Table 2 responded significantly to N-fertilizer levels where, increasing N-fertilizer level up to 90 kg/fad significantly increased plant height and chlorophyll content of ear leaf during both seasons and their combined analysis. Ear leaf area was also increased due to increasing nitrogen fertilizer level up to 90 kg N/fad during the second season, while the results of the first season confirmed by combined analysis presented positive significant response of ear leaf area to increasing nitrogen fertilizer level up to 135 kg N/fad. Such results were generally expected, since nitrogen element is an important component in many biological compounds that plays a major role in photosynthetic activity, protein synthesis (Hirel *et al*., 2005). Also it is a part of the enzymes associated with chlorophyll synthesis (Chapman and Barreto, 1997). Furthermore, deficiency of nitrogen leads to loss green color in leaves, decrease leaf area and intensity of photosynthesis (Gastal and Lemaire, 2002) which in turn boots up maize growth traits. In this manner, Ahmed and El-Sheikh (2002) and Abd El-Maksoud and Sarhan (2008) recorded significant increments in all studied growth traits by increasing nitrogen fertilizer level up to 140 kg N/fad.

Table 5. Means of kernel weight/ear (g), shelling percentage (%) and grain yield (ton/fad.) of the two maize hybrids as affected by irrigation intervals and nitrogen fertilizer level during two successive summer seasons (2011 and 2012) as well as their combined

Main effects and interactions	Kernel weight/ear (g)			Shelling %			Grain yield (ton/fad.)		
	2011	2012	Comb.	2011	2012	Comb.	2011	2012	Comb.
Irrigation intervals(I):									
12 days	192.04 a	175.43 a	183.74 a	84.8	83.5	84.2	4.41 a	3.69 a	4.05 a
16 days	187.02 a	173.34 a	180.18 a	84.7	83.3	84.0	4.30 a	3.65 a	3.98 a
20 days	156.94 b	135.32 b	146.13 b	85.1	82.5	83.8	3.39 b	2.69 b	3.04 b
F-test	**	**	**	N.S	N.S	N.S	**	**	**
Hybrids (H):									
S.C.173	187.55	173.20	180.38	85.2	84.3	84.8	4.40	3.61	4.00
T.W.C. 352	169.80	149.52	159.66	84.5	81.9	83.2	3.67	3.08	3.37
F-test	*	**	**	N.S	*	N.S	*	*	*
Nitrogen fertilizer level (N):									
0.0 Kg N/fad. (control)	134.40 c	118.13 c	126.27 d	84.9	82.0	83.5	2.63 c	2.36 d	2.50 d
45.0 Kg N/fad.	164.43 b	139.88 c	152.16 c	84.7	83.5	84.1	3.72 b	2.85 c	3.29 c
90.0 Kg N/fad.	199.34 a	176.54 b	187.94 b	84.9	83.6	84.3	4.65 a	3.75 b	4.20 b
135.0 Kg N/fad.	216.52 a	210.88 a	213.70 a	85.0	83.3	84.2	5.10 a	4.41 a	4.76 a
F-test	**	**	**	N.S	N.S	N.S	**	**	**
Interactions:									
I x H	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
I x N	*	**	**	N.S	N.S	N.S	*	**	**
H x N	*	**	**	N.S	N.S	N.S	*	*	**

***,** and NS indicate significance at 0.05 and 0.01 levels and insignificancy of differences, in respective order.**

The results documented in Tables 3, 4 and 5 clearly showed that each increase in nitrogen fertilizer level up to 135 kg N/fad was accompanied with a significant increase in each of ear length, ear diameter and 100-kernel weight (in the 1st season and combined analysis) as well as kernel weight/ear and grain yield/fad (in the 2nd season and combined analysis). However, ear length, ear diameter and 100-kernel weight (in the 2nd season), number of kernels/row (in both growing seasons and their combined analysis), number of rows/ear, kernel weight/ear and grain yield/fad (in the 1st season) were significantly increased due to increasing nitrogen fertilizer level up to 90 kg N/fad. In addition, number of ears/plant was significantly increased with the first nitrogen dose applied (45 kg N/fad.), while, the further increment of nitrogen fertilizer level failed to increase number of ears/plant during both seasons and their combined which might be attributed that this trait mainly affected by genetic rather than environmental conditions. Finally the results concerned to number of rows/ear in the second season and the combined analysis as well as shelling percentage in both seasons and their combined analysis did not show any significant response to nitrogen fertilizer levels. The superiority of ear length and diameter may be due to the role of nitrogen in stimulating the building up of amino acids and growth hormones, this in turn acts positively in cell division and enlargement. In addition, nitrogen is an important component in many biological compounds that plays a major role in photosynthetic activity, protein synthesis and crop yield capacity (Hirel *et al*., 2005).

The consistent increase in grain yield /fad with each increase in nitrogen fertilizer level could be attributed to the increase of grain yield components (Table 3, 4 and 5) which were significantly influenced by growth traits that increased significantly by increasing N-levels (Table 2). The obtained results are in harmony with those reported by Attia *et al*. (2013) and El-Sobky *et al*. (2014) who recorded significant increase in grain yield and its attributes due to N addition of 120 Kg N/fad. Moreover, Nassr *et al*. (2015) found that, raising N-fertilizer level up to 150 kg N/fad was associated with significant increase in plant height, ear diameter, 100-grain weight and grain yield/fad.

D- Effect of interactions:

1- Interaction between irrigation intervals and nitrogen fertilizer levels

The interaction between irrigation intervals and nitrogen fertilizer levels clearly indicated that, under irrigation intervals of 12 or 16 days, kernel weight/ear and grain yield/fad showed positive response to N-fertilizer level up to 135 kg/fad. This effect of N-fertilizer was not observed when irrigation interval was prolonged to 20 days where these two traits were responded only to application of 90 kg N/fad. Under all N-fertilizer levels, kernel weight/ear and grain yield/fad significantly decreased when irrigation interval was prolonged from 12 or 16 to 20 days intervals (Fig. 1 A and B)

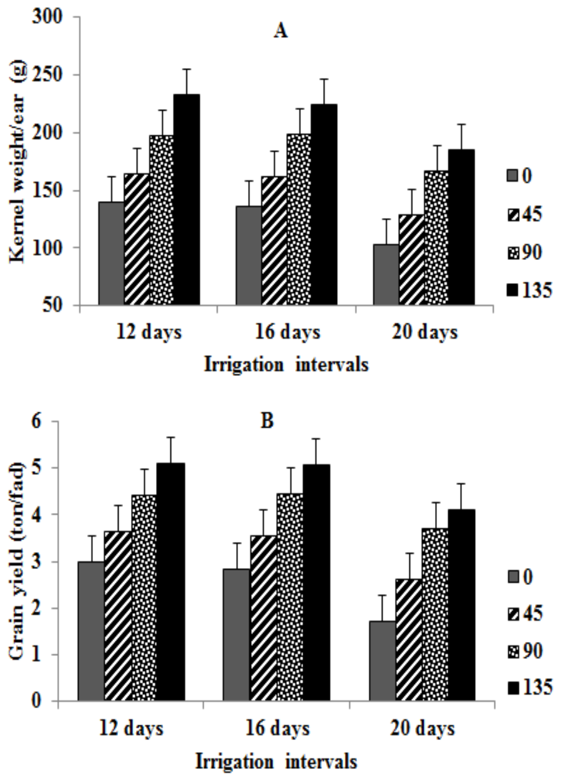

Fig 1. Effect of the interaction between irrigation intervals and nitrogen fertilizer levels on kernel weight/ear (A) and grain yield (B).

2- Interaction between maize hybrids and nitrogen fertilizer levels

Data graphically illustrated in Figures 2 (A, B and C) showed 100-kernel weight, kernel weight/ear and grain yield/fad as affected by the interaction between maize hybrids and N-fertilizer levels. It can be concluded that, the three aforementioned traits exhibited significant response to N-fertilizer increment up to 135 kg/fad, regarding SC 173, while TWC 352 responded only to N-fertilizer increment up to 90 kg/fad. In addition, SC 173 surpassed TWC 352 under all N-fertilizer levels in 100-kernel weight. Furthermore, SC 173 outyielded the other hybrid in kernel weight/ear under the application of 45 and 135 kg N/fad but, the two tested hybrids did not show significant differences when zero or 90 kg N/fad was applied. In addition, the two tested hybrids did not show significant differences in grain yield/fad when no N fertilizer was added, while, under any level on N fertilizer, SC 173 surpassed the other hybrid in grain yield/fad. Thus, the highest grain yield/fad (5.17 tons) was achieved by SC 173 hybrid when 135 kg N/fad was applied.

E- Grain yield response to nitrogen fertilization:

The response equations of grain yield to the increase of nitrogen level for the two studied hybrids was estimated and presented in Fig. 3. The hybrid SC173 presented linear non diminishing response, where the quadratic component of these equations (c) was significant while TWC352 presented diminishing response. This indicates that SC173 had high response to nitrogen level increasing and could be used under higher nitrogen levels, but TWC352 had received enough nitrogen to maximize its grain yield potentiality. And the predicted maximum nitrogen level for TWC352 which could have been used to maximize gain yield is 276 kg N/fad to achieve 5.12 ton/fad, while it is not economic. Where it could be expected from the figure that the economic level for this hybrid is 120 kg N/fad which could be achieved 4.2 ton/fad.

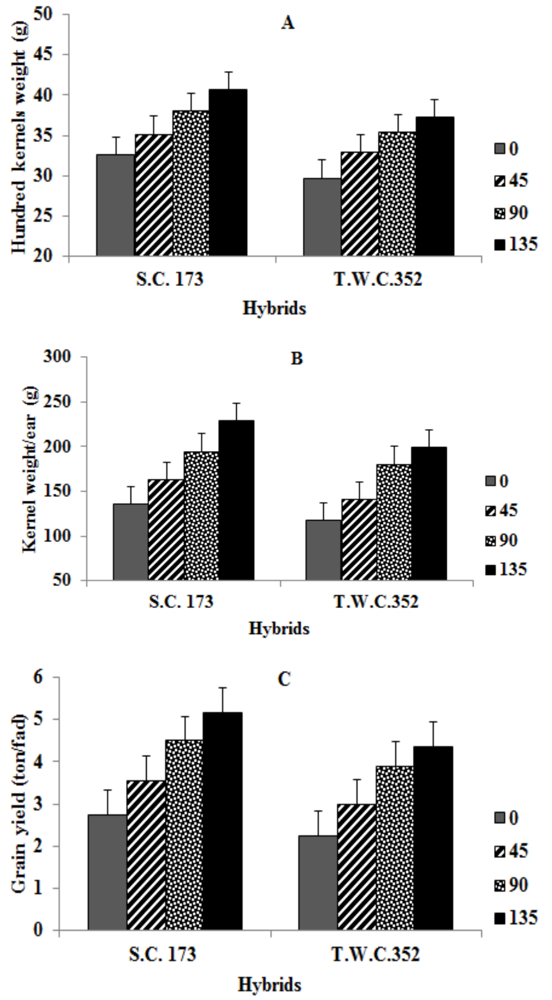

Fig 2. Effect of the interaction between hybrids and nitrogen fertilizer levels on hundred kernel weight (A), kernel weight/ear (B) and grain yield (C)

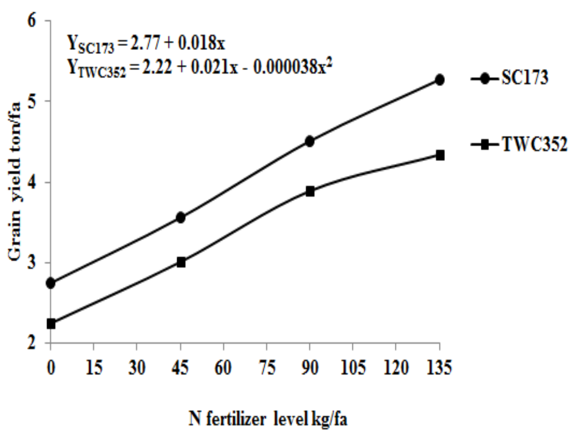

Figure 3. Grain yield response of two maize hybrids to N levels

CONCLUSION

It could be recommended that scheduling five irrigations in 16 days interval starting from the 2nd irrigation and addition of 135 kg N/fad for maximizing maize grain yield and its attributes and chosen SC 173 hybrid. Therefore, the total number of irrigations is seven only instead of nine i.e. saving two irrigations without any significant decrease in maize grain yield or its attributes. In addition, TWC 352 could be used under 90 kg N/fad without any significant decrease in grain yield. As well as, under water limitation, it could be used 20 days irrigation interval with 90 kg N/fad without significant reduction in grain yield.

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استجابة صنفين من الذرة الشامية الصفراء لفترات الرى ومعدلات السماد النيتروجينى

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أجريت هذه الدراسة فى المزرعة التجريبية التابعة لكلية الزراعة - جامعة الزقازيق بمنطقة غزالة حيث التربة الطينية – محافظة الشرقية – جمهورية مصر العربية خلال الموسمين الصيفيين المتتاليين ٢٠١١ و ٢٠١٢ بهدف دراسة استجابة صنفين من الذرة الشامية الصفراء (هجين فردى ١٧٣ وهجين ثلاثى ٣٥٢) لثلاث فترات رى (١٢، ١٦ و٢٠ يوم) وأربعة مستويات من السماد النيتروجينى (صفر، ٤٥، ٩٠ و ١٣٥ كجم ن/فدان) وقد أشارت نتائج التحليل المشترك للبيانات ما يلى: ١- لم تتأثر جميع الصفات تحت الدراسة بزيادة فترة الرى من ١٢ إلى ١٦ يوم بينما أدت زيادة فترة الرى من ١٢ أو ١٦ يوم إلى ٢٠ يوم إلى حدوث انخفاض معنوى فى كل صفات النمو ومحصول الحبوب وجميع مساهماته خلال موسمى الزراعة والتحليل المشترك للبيانات ماعدا صفة عدد السطور/الكوز فى الموسم الأول والتحليل المشترك.٢- تفوق الهجين الفردى ١٧٣ على الهجين الثلاثى ٣٥٢ فى كل صفات النمو المدروسة ومحصول الحبوب وجميع مساهماته ما عدا عدد الكيزان/النبات، عدد السطور/الكوز ونسبة التقشير والتى لم تختلف معنوياً بين الهجينين فى حين تفوق الهجين الثلاثى على الهجين الفردى فى صفة قطر الكوز.٣- حدوث زيادة معنوية فى صفات طول وقطر الكوز، وزن الـ ١٠٠ حبة، وزن الحبوب/الكوز ومحصول الحبوب/الفدان مع كل زيادة فى مستوى السماد النيتروجينى حتى ١٣٥ كجم ن/الفدان. كذلك زاد ارتفاع النبات، ومحتوى ورقة الكوز من الكلوروفيل وعدد الحبوب/السطر بزيادة معدل السماد النيتروجينى حتى ٩٠ كجم ن/الفدان. فى حين حدثت زيادة معنوية فى صفة عدد الكيزان/النبات بزيادة مستوى السماد النيتروجينى إلى ٤٥ كجم/الفدان. على الجانب الآخر، لم يتأثر عدد السطور/الكوز ونسبة التقشير بمستويات السماد النيتروجينى المستخدمة.٤- أشارت النتائج أن التفاعل بين عوامل الدراسة قد أدى إلى زيادة وزن الحبوب/الكوز ومحصول الحبوب/الفدان بزيادة مستوى السماد النيتروجينى حتى ١٣٥ كجم ن/الفدان عند فترتى الرى ١٢ و١٦ يوم. كذلك تفوق الهجين الفردى على الهجين الثلاثى فى صفات : وزن الـ ١٠٠ حبة، ووزن الحبوب/الكوز ومحصول الحبوب/الفدان عند استخدام المستوى الأعلى من السماد النيتروجينى (١٣٥ كجم ن/الفدان). لذا يمكن الحصول على أعلى إنتاجية من الذرة الشامية الصفراء عند استخدام الهجين الفردى ١٧٣ مع معدل السماد النيتروجينى ١٣٥ كجم/الفدان مع تطبيق فترات الرى كل ١٦ يوماً بدلاً من الرى كل ١٢ يوماً توفيراً لعدد الريات المضافة (ريتين) ومن ثم كميات المياه المستخدمة فى زراعة الذرة الشامية بدون أى نقص فى كمية المحصول تحت مثل هذه الظروف والظروف المشابهة فى مناطق أخرى. توصى نتائج هذه الدراسة بزراعة الهجين الفردى ١٧٣ والرى على فترات ١٦ يوم والتسميد بمعدل ١٣٥ كجم نيتروجين للفدان وذلك لمعظمة إنتاجية محصول الحبوب تحت ظروف الأراضى الطينية بمحافظة الشرقية – مصر.