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Effect of Irrigation Intervals on Growth, Productivity and Quality of Some Yellow Maize Genotypes

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TWO FIELD experiments were done at Experimental Farm, Faculty of Agriculture, Menoufia University, Shebin El- Kom, Egypt, during 2018 and 2019 seasons to study the effect of 3 irrigation intervals, i.e., irrigation every 12 (I_1), 17 (I_2) and 22 days (I_3) on growth, productivity and quality of 6 yellow maize genotypes (G), i.e., S.C 178, S.C 176, S.C 168, T.W.C 368, T.W.C 360 and T.W.C 352. The results could be summarized as follows:

1- Increasing irrigation intervals from 12 up to 17 and 22 days significantly decreased number and area of leaves and leaves, stem and total dry weight/plant, total chlorophyll, relative water content (RWC), plant height, length and diameter of ear, number and weight of grains/ear, 100 grain weight as well as grain, stover and biological yields/fed, protein and oil % and yields/fed, but significantly increased proline content in leaves in both seasons.

2- S.C 168 G surpassed the other genotypes in area and dry weight of leaves/plant, grain yield/fed, crop and harvest indices as well as protein yield/fed. T.W.C 368 G was superior in stem and total dry weight/plant, plant height, ear diameter, no.of grains/ear,100-grain weight as well as stover and biological yields/fed. However, S.C 168 G and T.W.C 368 G recorded the best values of RWC, no.of ears/plant, grain weight/ear, protein% and oil yield/fed as compared with the other genotypes. The highest significant values of proline content and no.of leaves/plant were obtained by T.W.C 352 G and T.W.C 360 G, respectively in both seasons.

3- Maize genotypes S.C 168 as well as T.W.C 360 and T.W.C 352 under I_2 and T.W.C 368 under either I_2 or I_3 had the lowest values of relative yield reduction and drought suS.Ceptibility index (< 1), indicating that those genotypes are relatively drought tolerant genotypes compared to other tested genotypes in our experiment condition.

Keywords: Drought stress, Grain yellow genotypes, Irrigation intervals, Maize, Yield and its components.

Introduction

Maize (*Zea mays* L.) is an important cereal crop (Family Poaceae) which ranks the third after wheat and rice. In Egypt, it is used as human food, livestock and poultry feed as well as a row material for industrial products such as oil and starch. The local production of maize dose not sufficient to meet the excessive demand especially the yellow grains. Therefore, any attempts for raising maize production are considered a matter of utmost importance. Such attempts could be achieved either by increasing its cultivated area or by the productivity of unit area using high yielding hybrids as well as improving the culture practices. It is well known that maize crop had high irrigation requirements as well as it is sensitive crop to water stress during some growth stages (Ahmadi et al., 2010; Kotb & Mansour, 2012; Mubeen et al., 2013; Khatab et al., 2015). Therefore, the optimal water management strategies become an important factor for raising maize production due to limitations in the irrigation water supply in Egypt.

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Proper irrigation interval can play a major role in increasing water use efficiency and productivity by applying the required amount of water when it is needed. Many investigators found the growth and productivity of maize were increased by the application of adequate water irrigation every 10 days (Gomaa et al., 2014; El-Sobky & Desoky, 2017; Abo El-Ezz & Haffez, 2019) or 12 days (Yasin, 2016), 14 days (Solieman et al., 2019) and 15 days (Gomaa et al., 2015) as compared with prolonging irrigation intervals more than those periods. On the other hand, exposing maize plants to water stress condition by skipping one or more irrigations caused a depression in the yield and its components of maize as reported by Ashraf et al. (2016), El-Sobky & El-Naggar (2017), Mohammed et al. (2017) and Li et al. (2018). Under the minimum water conditions, the best option for maize production, yield improvement and yield stability is growing varieties are more tolerant for drought stress (Gabr et al., 2018; Hategekimana et al., 2018).

The main objectives of this research are to determine the growth, yield and quality of some yellow maize genotypes grown under different irrigation intervals as well as detect the most efficient genotype grown under drought stress conditions which produce high yielding.

Materials and Methods

Two field experiments were done at Experimental Farm, Faculty of Agriculture, Menoufia University, Shebin El- Kom, Egypt (Latitude: 30° 33' 31'' and Longitude: 31° 00' 36''), during 2018 and 2019 seasons. The aim of the experiment was studying the effect of three irrigation intervals (irrigation every 12, 17 and 22 days) on growth, productivity and quality of six yellow maize genotypes, i.e., 3 single crosses (S.C. 178 , S.C. 176 and S.C. 168) and 3 three ways cross (T.W.C. 368 , T.W.C. 360 and T.W.C. 352). Schedule of time and number of irrigations for the tested irrigation interval treatments at plant growth periods are shown in Table 1.

Strip plot design with three replications was used in this experiment, where the horizontal plots (from north to south direction) were devoted to the irrigation intervals and the vertical plots (from east to west direction) were allocated by the maize genotypes. The size of each plot was 12.6m^2 included 6 rows, 3m length and 0.7m width for each. The preceding crops were Egyptian clover (*Trifolium alexandrinum* L.) and wheat (*Triticum* sp. L.) in the first and second seasons, respectively. The grains of the six tested maize genotypes were obtained from Agriculture Research Centre, Ministry of Agriculture, Egypt. The maize grains were sown in hills 25cm apart at 20th and 14th May in 2018 and 2019 seasons, respectively at a rate of 10kg grains/fed in both seasons. The plants were thinned to one plant/ hill before the first irrigation producing 24000 plants/fed. Phosphorus fertilizer was applied pre sowing for each plot at a rate of 100kg/ fed as calcium super phosphate (15.5% P_2O_5). Nitrogen fertilizer was applied in the form of urea (46.5% N) in the two equal doses, the first and second doses were applied prior the first and the second irrigations in both seasons. The plants were harvested at 7 and 6 September, i.e. 110 and 115 days after sowing (DAS) in the first and second seasons, respectively. The maximum and minimum air temperature during the growth periods are shown in Table 2a.

The physical and chemical properties of the experimental soil were determined in the top soil (0-30cm) as described by Jackson (1973) and Chapman & Pratt (1978) as presented in Table 2b.

TABLE 1. Time and number of irrigations at each tested irrigation interval treatment.

Irrigation intervals \ No. of irrigations	Time of irrigation (days after sowing, DAS)							Total
	1st	2nd	3rd	4th	5th	6th	7th	
(I_1) 12 days Normal irrigation	20	32	44	56	68	80	92	7
(I_2) 17 days Moderate drought stress	20	37	54	71	88	-	-	5
(I_3) 22 days Severe drought stress	20	42	64	86	-	-	-	4

TABLE 2a. Air temperature (ºC) during the growth periods in 2018 and 2019 seasons.

Seasons \ Months		May	June	July	August	September
2018	Max.	32.11	35.62	35.61	34.67	29.31
	Min.	19.72	23.05	24.22	23.41	22.85
2019	Max.	38.22	32.56	33.97	35.27	34.57
	Min.	21.87	24.63	24.67	25.13	24.58

Source: Central Laboratory for Agricultural Climate, Agricultural Research Center, Ministry of Agriculture & Land Reclamation, Egypt.

TABLE 2b. Physical and chemical properties of the experimental soil in 2018 and 2019 seasons.

Seasons \ Properties	Texture class	Field capacity %	Permanent wilting point %	Available water %	pH	E.C. ds/m	O.M. %	Available nutrients (ppm)		
								N	P	K
2018	Clay loam	39.4	19.8	19.6	7.32	0.63	1.79	31.5	9.8	327.2
2019	Clay loam	39.2	19.9	19.3	7.14	0.67	1.71	30.8	9.3	330.7

Characters studied

Growth characters

At 60 DAS, five guarded plants were taken at random to determine the following growth characters/ plant: No. of leaves, leaf area "blade"; cm^2 (Blade length x maximum blade width x 0.75) as described by Stickler (1964), stem dry weight (stem + sheaths); g, leaves dry weight (blade); gand total dry weight (stem + leaves); g.

Physiological attributes

At 65 DAS, the following physiological attributes were estimated:

1- Total chlorophyll: It was estimated from the 4^{th} leaf of plant in each plot using SPAD meter (SPAD 502, Minolta, Japan).

2- Proline content in leaves (mg/g DW): It was determined using the method described by Bates et al. (1973) as a physiological indicator of plant status under the implemented water stress treatments.

3- Relative water content (RWC %): It was measured using the following formula (Barrs, 1968):

RWC %= (FW–DW)/ (TW–DW) × 100

where FW: Fresh weight of leaf sample, DW: Dry weight of leaf sample and TW: Turgid weight of leaf sample (soaked on distilled water for 4hrs).

Yield and yield components

At harvest, five plants were taken from the three inner rows in each plot at random to determine the following characters of yield components: Plant height; cm, no. of ears/ plant, ear length; cm, ear diameter; cm, no. of grains/ ear, 100 grain weight; gand grain weight/ ear; g. Moreover, grain, stover and biological yields/ fed (fed= $4200m^2$) were determined from the rest plants in each plot. Translocation indices % (crop and harvest indices) were also calculated using the following formula:

Crop index %= grain yield/ stover yield X 100

Harvest index %= grain yield/ biological yield X 100

Grain quality

At harvest, grain samples were dried in air-oven at 70˚C to constant weight before grinding with a mill to pass through a 0.5mm sieve. The samples were chemically analyzed to determine nitrogen % in the grains by Micro-Kjeldahl unit. Protein % in the dry samples was calculated by multiplying nitrogen % by the factor of 5.75. Oil % in the grains was determined using soxhlet extraction apparatus. Nitrogen and oil % were determined according to the methods described by AOAC (2000). Also, protein and oil yields/ fed (kg/ fed) were calculated by multiplying protein and oil percentages by grain yield/ fed.

Drought tolerance indices

The following drought tolerance indices have been performed to identify drought tolerance genotypes considering grain yield potential in both normal and stress conditions:

1- Tolerance index (TOL)= Y_P - Y_S according to Hossain et al. (1990).

2- Relative yield reduction % (RYR)= 1 – (Ys / Yp) according to Golestani & Assad (1998).

3- Drought susceptibility index (DSI) was calculated according to Fischer & Maurer (1978).

$$DSI = \frac{1 - Ys/Yp}{1 - \bar{Y}s/\bar{Y}p}$$

where, Ys and Yp represent grain yield of each genotype under stress and normal conditions, respectively. $\bar{Y}$s and $\bar{Y}$p represent means of grain yield of all genotypes under stress and normal conditions, respectively. The genotype could be considered tolerant to drought stress condition when it had DSI value less than unity (< 1) and/ or recorded low values of TOL and RYR %.

Statistical analysis

The data were statistically analyzed according to the methods described by Snedecor & Cochran (1994). Duncan`s multiple range test (Duncan, 1955) was used to compare the treatment means. The mean values designated by the same letter (s) in each column are not significantly at 5% level.

Results and Discussion

Growth characters

The data of growth characters studied at 60 DAS, i.e. no. of leaves, leaf area and leaves, stem and total dry weight/ plant of the tested six yellow maize genotypes under three irrigation intervals (12, 17 and 22 days) and their interactions are presented in Table 3 in the first 2018 and second 2019 seasons.

Concerning the irrigation intervals effect, all growth characters studied were significantly decreased by 7.51 and 20.35% (for no. of leaves/ plant), 6.62and 15.08% (for leaf area/ plant), 8.87 and 17.38% (for leaves dry weight/ plant), 9.44 and 25.20% (for stem dry weight/ plant), 9.11 and 21.97% (for total dry weight/ plant) by prolonging irrigation intervals from 12 days (normal) up to 17 days (moderate stress) and 22 days (severe stress), respectively, as an average of the two seasons. The reduction in growth traits obtained as increasing irrigation intervals may be due to water stress condition leads to a decrease in root and shoot development (Sangakkara et al., 2010; Ashagre, 2014), some growth stimulating hormone such as IAA (Al-Sheikh et al., 2015), tissue volume (El-Sobky & Desoky, 2017) and cell growth (Ouda et al., 2006) and consequently reduced the growth of maize plant such as no. of leaves/ plant (Hameedi et al., 2015), leaf area plant (Abo-Marzoka et al., 2016) and dry matter production/ plant (Kubota et al., 2016; Shinoto et al., 2018).

Significant differences were detected among the tested six maize genotypes in all growth characters studied in the two seasons. T.W.C. 360 genotype produced the greatest number of leaves/ plant without significant differences with T.W.C. 368, S.C. 168, S.C. 176 and S.C. 178 genotypes in both seasons. However, S.C. 168 genotype surpassed the other ones in each of leaf area and leaves dry weight/ plant in the two seasons. The maximum values of stem and total dry weights/ plant were recorded by T.W.C. 368 genotype in both seasons. Reversely, T.W.C. 352 genotype had the lowest values of all growth characters studied in the two seasons. The differences among the tested maize genotypes in the growth characters may be attributed to the differences in their genetical makeup. In this connection, Darwich (2018) found variation among eight yellow maize hybrids namely S.C. 162, S.C. 166, S.C. 167, S.C. 168, S.C. 177, S.C. 178, T.W.C 360 and T.W.C 368 in their number of leaves and leaf area/ plant in favor of T.W.C 368 hybrid over two seasons.

TABLE 3. Growth characters of maize genotypes as affected by irrigation intervals and their interaction (at 60 DAS).

Treatments \ Characters		No. of leaves/ plant		Leaf area/ plant (cm^2)		Dry weight/ plant (g)					
						Leaves		Stem		Total	
		2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
Irrigation intervals (I)											
I_1		18.11 a	18.11 a	8078.45 a	7873.11 a	50.58 a	51.86 a	72.38 a	71.71 a	122.95 a	123.57 a
I_2		16.52 b	16.98 b	7602.14 b	7294.05 b	47.01 b	46.32 b	66.86 b	63.63 b	113.87 b	109.86 b
I_3		14.32 c	14.53 c	6909.70 c	6637.88 c	42.06 c	42.56 c	51.41 c	56.34 c	93.47 c	98.90 c
Genotypes (G)											
S.C 178		16.13 ab	16.37 ab	7606.65 ab	7312.02 bc	47.81 bc	47.31 ab	64.39 b	64.58 b	112.20 b	111.89 bc
S.C 176		16.27 ab	16.28 ab	7542.14 ab	7233.74 c	43.36 d	45.82 b	64.20 b	65.34 b	107.76 c	111.16 c
S.C 168		16.27 ab	16.75 ab	7718.86 a	7543.25 a	49.48 a	49.06 a	65.56 b	65.92 b	115.04 a	114.99 ab
T.W.C 368		16.58 ab	16.93 a	7631.05 ab	7495.10 ab	49.11 ab	48.89 a	67.97 a	68.48 a	117.08 a	117.37 a
T.W.C 360		16.80 a	17.22 a	7425.73 bc	7316.60 bc	47.43 c	46.70 b	60.12 c	60.11 c	107.55 c	106.81 d
T.W.C 352		15.87 b	15.68 b	7256.13 c	6709.60 d	41.90 e	43.50 c	59.06 c	58.93 c	100.96 d	102.43 e
Interaction (I x G)											
I_1	S.C 178	17.93 a	17.67 a	8092.92 bc	7819.47 a	50.93 a	52.54 b	73.62 a	70.90 a	124.54 a	123.44 a
	S.C 176	18.00 a	17.40 a	8054.73 bc	7783.10 a	47.96 a	48.72 c	72.34 a	72.06 a	120.31 a	120.78 a
	S.C 168	18.33 a	18.53 a	8547.78 a	8252.78 a	54.12 a	55.49 a	75.31 a	74.55 a	129.43 a	130.04 a
	T.W.C 368	18.07 a	19.73 a	8183.25 b	8003.13 a	52.75 a	53.84 ab	80.15 a	76.83 a	132.90 a	130.66 a
	T.W.C 360	18.67 a	18.93 a	8023.70 bcd	7911.62 a	51.73 a	52.87 b	66.85 a	69.36 a	118.57 a	122.23 a
	T.W.C 352	17.67 a	16.40 a	7568.33 efg	7468.61 a	45.96 a	47.68 c	66.01 a	66.61 a	111.96 a	114.29 a
I_2	S.C 178	16.13 a	17.13 a	7771.74 c-f	7561.41 a	48.36 a	46.81 cd	67.49 a	65.66 a	115.86 a	112.48 a
	S.C 176	16.40 a	16.93 a	7668.65 def	7194.47 a	44.45 a	44.84 de c	68.79 a	66.64 a	113.24 a	111.48 a
	S.C 168	16.53 a	17.67 a	7927.15 b-e	7635.75 a	49.73 a	47.74 c	68.61 a	65.55 a	118.34 a	113.29 a
	T.W.C 368	16.67 a	16.33 a	7591.48 ef	7508.17 a	48.82 a	47.70 c	69.30 a	68.54 a	118.12 a	116.24 a
	T.W.C 360	17.07 a	17.20 a	7430.84 fgh	7268.30 a	47.93 a	47.15 cd	64.26 a	57.49 a	112.19 a	104.64 a
	T.W.C 352	16.33 a	16.67 a	7222.95 ghi	6596.23 a	42.77 a	43.15 e	62.73 a	57.91 a	105.50 a	101.06 a
I_3	S.C 178	14.33 a	14.33 a	6955.30 ijk	6555.18 a	44.15 a	42.58 e	52.06 a	57.20 a	96.21 a	99.78 a
	S.C 176	14.40 a	14.53 a	6903.02 ijk	6723.65 a	38.26 a	43.91 e	51.46 a	57.32 a	89.73 a	101.23 a
	S.C 168	13.93 a	14.07 a	6681.66 k	6741.23 a	44.58 a	43.96 e	52.77 a	57.67 a	97.35 a	101.64 a
	T.W.C 368	15.00 a	14.73 a	7118.43 hij	6974.02 a	45.76 a	45.14 de	54.46 a	60.10 a	100.22 a	105.23 a
	T.W.C 360	14.67 a	15.53 a	6977.10 ijk	6769.28 a	42.62 a	40.09 f	49.27 a	53.49 a	91.89 a	93.58 a
	T.W.C 352	13.60 a	14.00 a	6822.66 jk	6063.96 a	36.98 a	39.69 f	48.44 a	52.27 a	85.42 a	91.96 a

Irrigation intervals: I_1, I_2 and I_3= 12, 17 and 22 days, respectively.

The interaction between the irrigation intervals and the tested maize genotypes was significant for leaf area/ plant in the first season and leaves dry weight/ plant in the second season. The differences among the tested genotypes for such traits were more pronounced when the plants were irrigated every 12 days (normal irrigation) than they were irrigated every 17 and 22 days (moderate and severe stress drought), respectively. The highest values of leaf area/ plant (8547cm^2) in the first season and leaves dry weight (55.49g) in the second season were achieved by growing S.C. 168 genotype under the normal irrigation. However, T.W.C 352 genotype produced the lowest values (6822.7cm^2 and 39.69g) for the same respective traits when it was irrigated under severe drought stress. On the other hand, the rest growth character studied herein were not significantly affected by the interaction between the two factors in the first and/ or second season. This means that the behavior of the tested maize genotypes was stable under different irrigation stress conditions for those traits.

Physiological attributes

Table 4 included the data of physiological attributes studied in the leaf, i.e. total chlorophyll (Chl.), proline content (PC) and relative water content (RWC %) of the tested maize genotypes as affected by various irrigation intervals and their interactions in both seasons.

TABLE 4. Physiological attributes of maize genotypes as affected by irrigation intervals and their interaction (at 65 DAS).

Treatments \ Characters		Total chlorophyll (SPAD)		Proline (mg/g DW)		RWC %	
		2018	2019	2018	2019	2018	2019
Irrigation intervals (I)							
I_1		46.22 a	44.06 a	0.652 c	0.678 c	76.39 a	78.12 a
I_2		42.61 b	41.66 ab	0.769 b	0.783 b	73.37 b	72.55 b
I_3		41.38 c	39.22 b	0.907 a	0.910 a	68.84 c	66.49 c
Genotypes (G)							
S.C 178		43.41 a	42.38 a	0.783 c	0.809 c	70.73 c	70.41 c
S.C 176		43.49 a	41.59 a	0.764 d	0.779 d	72.24 b	72.33 b
S.C 168		44.04 a	42.99 a	0.724 e	0.730 f	77.02 a	77.67 a
T.W.C 368		43.41 a	41.88 a	0.729 e	0.740 e	76.28 a	77.41 a
T.W.C 360		43.54 a	40.87 a	0.809 b	0.828 b	72.04 b	69.34 d
T.W.C 352		42.53 a	40.16 a	0.847 a	0.860 a	68.88 d	67.17 e
Interaction (I_X G)							
I_1	S.C 178	46.38 a	45.11 a	0.657 jk	0.681 j	74.69 cd	76.22 d
	S.C 176	46.18 a	43.73 a	0.641 kl	0.671 j	76.17 c	77.65 c
	S.C 168	47.37 a	46.61 a	0.606 m	0.632 l	80.70 a	83.14 a
	T.W.C 368	45.66 a	43.37 a	0.631 l	0.652 k	79.22 b	81.14 b
	T.W.C 360	46.75 a	42.35 a	0.671 j	0.702 I	75.03 cd	76.04 d
	T.W.C 352	45.00 a	43.20 a	0.705 i	0.733 j	72.51 e	74.55 e
I_2	S.C 178	42.67 a	41.83 a	0.770 f	0.791 f	71.47 e	71.19 g
	S.C 176	43.05 a	42.74 a	0.743 g	0.772 g	72.82 e	73.71 e
	S.C 168	43.41 a	43.19 a	0.705 i	0.719 hi	77.96 b	80.14 b
	T.W.C 368	42.48 a	41.43 a	0.723 h	0.734 h	75.20 cd	78.72 c
	T.W.C 360	42.43 a	40.60 a	0.815 e	0.830 e	72.87 e	66.53 i
	T.W.C 352	41.63 a	40.17 a	0.861 d	0.852 d	69.87 f	65.07 j
I_3	S.C 178	41.20 a	40.20 a	0.924 bc	0.946 b	66.01 h	63.83 k
	S.C 176	41.23 a	38.31 a	0.909 c	0.895 c	67.72 g	65.64 ij
	S.C 168	41.33 a	39.20 a	0.861 d	0.840 de	72.41 e	69.75 h
	T.W.C 368	42.10 a	40.83 a	0.833 e	0.835 de	74.42 d	72.40 f
	T.W.C 360	41.43 a	39.67 a	0.940 b	0.954 b	68.22 g	65.47 ij
	T.W.C 352	40.97 a	37.13 a	0.975 a	0.994 a	64.27 i	61.91 l

Irrigation intervals: I_1, I_2 and I_3= 12, 17 and 22 days, respectively.

Providing the plants with sufficient soil moisture (irrigation every 12 days) caused a significant increase in Chl. and RWC % in both seasons. The superiority of Chl. and RWC % values obtained herein may be due to the abundance irrigation water levels encourage the absorption of water and nutrients in the cells which enhancing their volume and photosynthesis efficiency. In this concern, many investigators reported that providing the maize plants with adequate moisture by shortening irrigation intervals leads to an increase in Chl. as reported by Gomaa et al. (2014), Yasin (2016), Abo-Marzoka et al. (2016) and El-Sobky & Desoky (2017) and RWC as reported by Lama & Chakraborty (2013) and Farouk et al. (2018). Reversely, exposing maize plants to drought stress condition (irrigation every 22 days) caused an increment in the values of PC. Similar results were obtained by Lama & Chakraborty (2013), Gomaa et al. (2015), Farouk et al. (2018)and Abo EL-Ezz & Haffez (2019) found that the values of PC was increased under drought stress by increasing irrigation water intervals.

The varietal differences were significant for PC and RWC % in the leaves of the tested genotypes, while such differences were not great enough to reach the 5 % level of significance for Chl. values in both seasons. T.W.C 352 genotype registered the highest significant values of PC (0.847and 0.860mg/g DW), but the lowest significant values of RWC % (68.88 and 67.17%) in the first and second seasons, respectively. In this respect, other investigators found that PC and RWC % in the leaves significantly differed among some maize varieties, where the high yielding ability varieties have more values of RWC % (Ali , 2016), but have lower values of PC (Tarighaleslami et al., 2012; Gomaa et al., 2017).

The interaction between the two tested factors was found to be significant in PC and RWC % in the two seasons. However, the interaction effect was not significant for Chlorophyll content in both seasons, indicating that each factor affected independently. Growing S.C. 168 genotype gave the lowest values of PC (0.619and 0.712mg/g DW) but the highest values of RWC % (81.92 and 79.05%) when its plants were irrigated every 12 (I_1)and 17 (I_2) days, respectively, as an average of the two seasons. Reversely, T.W.C 368 genotypes had the lowest values of PC (0.834mg/g DW) and the highest values of RWC % (73.41%) when the plants were irrigated every 22 days (I_3), as an average of the two seasons. From these results, it can be concluded that S.C. 168 genotype was considered suitable under normal irrigation and moderate drought stress conditions, while T.W.C 368 genotype considered tolerant to severe drought stress condition. In this respect, Ahmadi et al. (2010) reported that maize plant responses to drought stress include accumulation of compatible osmolytes in cells such as proline to mitigate the stress injury.

Yield components

Data presented in Table 5 showed the effect of irrigation intervals and varietal differences of the tested maize genotypes and their interaction on yield components studied at harvest in both seasons.

There are significant and gradual reduction in each of plant height, ear length and diameter, no. of grains/ ear, 100 grain weight and grain weight/ ear by increasing the irrigation intervals from 12 to 17 and 22 days in the two seasons. However, the tested irrigation intervals had not any significant effect in the no. of ears/ plant in both seasons. The depression in the aforementioned yield components obtained herein by prolonging the irrigation intervals may be due to the significant reduction in the growth characters (number and area of leaves and dry matter accumulation/ plant) as well as in the physiological constituents in the leaves (total chlorophyll and relative water content) as previously discussed in Tables 3 and 4, respectively. In this connection, many researchers found that exposing maize plants to drought stress by prolonging irrigation intervals caused an inhibition in plant height (Gabr et al., 2018; Shinoto et al., 2018), ear length and diameter (Ibrahim & Kandil, 2007; Yasin , 2016), number of grains/ ear and 100 grain weight (Gomaa et al., 2015; Abo-Marzoka et al., 2016) and grain weight/ ear (El-Sobky & Desoky, 2017; Farouk et al., 2018).

Concerning the varietal differences, it can be noticed that T.W.C 368 genotype significantly surpassed the other tested genotypes in plant height and ear diameter as well as grain weight/ ear and its components (no. of grains/ ear and 100 grain weight). However, S.C 168 and T.W.C 360 genotypes were significantly higher than the other genotypes in no. of ears/ plant and ear length, respectively in both seasons. Reversely, T.W.C 352 genotype produced mostly the lower significant values of yield components studied. The superiority of T.W.C 368 genotype in grain weight/ ear and its components may be due to the increment in total dry matter accumulation as resultants of the increase of number of leaves and leaf area/ plant as previously discussed in Table 3 as well as RWC in the leaves as presented in Table 4. The varietal differences among some yellow maize genotypes were obtained also by other researchers such as Ali (2016) and Balbaa & Awad (2018) for ear length and diameter, Gomaa et al. (2017) for plant height and no. of grains/ ear and Yasin (2016) and Fathy et al. (2019) for 100 grain weight and grain weight/ ear.

TABLE 5. Yield components of maize genotypes as affected by irrigation intervals and their interaction.

Treatments \ Characters		Plant height (cm^2)		No. of ears/ plant		Ear length (cm)		Ear diameter (cm)	
		2018	2019	2018	2019	2018	2019	2018	2019
Irrigation intervals (I)									
I_1		292.04 a	289.73 a	1.22 a	1.15 a	28.26 a	29.74 a	4.73 a	4.47 a
I_2		272.11 b	278.69 b	1.05 a	1.05 a	24.20 b	23.55 b	4.36 b	4.30 b
I_3		256.93 c	258.36 c	0.95 a	0.96 a	21.58 c	21.91 c	4.22 c	4.17 c
Genotypes (G)									
S.C 178		269.33 c	272.97 bc	1.03 bc	1.01 bc	24.84 c	25.34 bc	4.36 c	4.24 b
S.C 176		279.52 ab	277.79 b	1.1 ab	1.08 ab	25.71 b	26.00 a	4.48 b	4.33 ab
S.C 168		276.08 b	274.66 b	1.22 a	1.16 a	23.89 d	24.91 cd	4.54 b	4.34 ab
T.W.C 368		284.33 a	287.05 a	1.11 ab	1.11 a	23.67 d	24.47 d	4.71 a	4.50 a
T.W.C 360		268.14 c	272.90 bc	1.03 bc	1.01 bc	27.32 a	26.62 a	4.19 d	4.17 b
T.W.C 352		264.76 c	268.20 c	0.97 c	0.94 c	22.65 e	23.06 e	4.31 cd	4.31 ab
Interaction (I $_x$ G)									
I_1	S.C 178	283.53 cde	286.87 a	1.17 a	1.08 a	28.40 c	29.75 a	4.82 a	4.36 a
	S.C 176	297.30 ab	292.01 a	1.25 a	1.17 a	29.46 b	30.91 a	4.75 a	4.55 a
	S.C 168	294.50 abc	288.53 a	1.42 a	1.33 a	27.61 cd	29.34 a	4.86 a	4.52 a
	T.W.C 368	303.63 a	301.84 a	1.25 a	1.25 a	26.81 d	29.37 a	5.01 a	4.73 a
	T.W.C 360	287.61 bcd	287.12 a	1.17 a	1.08 a	31.59 a	32.19 a	4.38 a	4.23 a
	T.W.C 352	285.71 cd	282.04 a	1.08 a	1.00 a	25.74 e	26.88 a	4.56 a	4.45 a
I_2	S.C 178	268.75 fg	276.56 a	1.00 a	1.00 a	24.62 f	24.15 a	4.21 a	4.27 a
	S.C 176	277.79 def	281.03 a	1.08 a	1.08 a	25.47 ef	24.75 a	4.41 a	4.28 a
	S.C 168	272.84 efg	277.01 a	1.25 a	1.17 a	23.00 gh	23.64 a	4.45 a	4.36 a
	T.W.C 368	282.55 de	290.85 a	1.08 a	1.08 a	23.08 g	22.35 a	4.64 a	4.42 a
	T.W.C 360	267.25 fgh	276.15 a	1.00 a	1.00 a	27.14 d	25.15 a	4.19 a	4.19 a
	T.W.C 352	263.49 gh	270.61 a	0.93 a	0.97 a	21.90 hi	21.28 a	4.28 a	4.33 a
I_3	S.C 178	255.74 hi	255.49 a	0.93 a	0.97 a	21.52 i	22.12 a	4.07 a	4.10 a
	S.C 176	263.49 gh	260.34 a	0.97 a	1.00 a	22.22 ghi	22.36 a	4.31 a	4.17 a
	S.C 168	260.89 gh	258.45 a	1.00 a	1.00 a	21.09 ij	21.77 a	4.33 a	4.15 a
	T.W.C 368	266.83 fgh	268.49 a	1.00 a	1.00 a	21.13 ij	21.71 a	4.51 a	4.35 a
	T.W.C 360	249.58 i	255.44 a	0.93 a	0.97 a	23.23 g	22.52 a	4.02 a	4.11 a
	T.W.C 352	245.10 i	251.97 a	0.90 a	0.87 a	20.32 j	21.02 a	4.10 a	4.17 a

Irrigation intervals: I_1, I_2 and I_3= 12, 17 and 22 days, respectively.

TABLE 5. Cont.

Treatments \ Characters		No. of grains/ ear		100 grain weight (g)		Grain weight/ ear (g)	
		2018	2019	2018	2019	2018	2019
Irrigation intervals (I)							
I_1		652.00 a	630.44 a	33.63 a	34.02 a	219.79 a	208.75 a
I_2		586.16 b	555.11 b	32.12 b	32.58 b	181.29 b	168.71 b
I_3		510.72 c	509.66 c	29.91 c	29.54 c	162.33 c	155.37 c
Genotypes (G)							
S.C 178		564.88 cd	548.88 cd	31.88 bc	31.75 bc	184.60 c	175.87 c
S.C 176		582.88 bc	566.22 bc	31.65 c	32.15 bc	192.48 b	181.11 b
S.C 168		598.66 b	576.00 b	32.31 b	32.31 b	195.48 ab	185.76 ab
T.W.C 368		618.88 a	603.33 a	33.09 a	33.60 a	200.41 a	190.65 a
T.W.C 360		578.88 c	558.88 bcd	31.01 d	30.92 d	176.41 d	171.02 c
T.W.C 352		553.55 d	537.33 d	31.40 cd	31.53 cd	171.43 d	161.25 d
Interaction (I x G)							
I_1	S.C 178	624.67 de	612.67 a	33.76 a	33.38 a	212.83 cd	206.57 a
	S.C 176	658.00 bc	631.33 a	32.88 a	33.88 a	220.59 bc	211.94 a
	S.C 168	671.00 ab	654.00 a	33.96 a	34.89 a	223.54 ab	217.64 a
	T.W.C 368	692.67 a	677.00 a	34.71 a	35.80 a	231.66 a	224.96 a
	T.W.C 360	653.00 bcd	619.67 a	33.12 a	33.03 a	207.78 d	201.43 a
	T.W.C 352	612.67 e	588.00 a	33.40 a	33.16 a	204.37 d	189.98 a
I_2	S.C 178	567.00 f	536.33 a	31.56 a	33.07 a	179.74 fgh	168.32 a
	S.C 176	577.33 f	550.00 a	32.89 a	32.90 a	185.30 efg	170.01 a
	S.C 168	610.00 e	559.67 a	32.28 a	31.71 a	189.37 ef	174.76 a
	T.W.C 368	637.33 cde	595.33 a	33.78 a	33.91 a	192.26 e	178.96 a
	T.W.C 360	573.67 f	548.00 a	30.83 a	31.57 a	173.30 hi	165.55 a
	T.W.C 352	551.67 fg	541.33 a	31.43 a	32.36 a	167.82 ij	154.72 a
I_3	S.C 178	503.00 h	497.67 a	30.34 a	28.82 a	161.26 j	152.72 a
	S.C 176	513.33 h	517.33 a	29.20 a	29.68 a	171.56 hi	161.38 a
	S.C 168	515.00 h	514.33 a	30.70 a	30.36 a	173.55 hi	164.91 a
	T.W.C 368	526.67 gh	537.67 a	30.79 a	31.11 a	177.31 ghi	168.05 a
	T.W.C 360	510.00 h	508.33 a	29.09 a	28.17 a	148.17 k	146.09 a
	T.W.C 352	496.33 h	482.67 a	29.37 a	29.10 a	142.13 k	139.08 a

Irrigation intervals: I_1, I_2 and I_3 = 12, 17 and 22 days, respectively.

The interaction effect between the tested maize genotypes and irrigation intervals was significant for plant height, ear length, no. of grains/ear and grain weight/ ear in the first season. However, there are no significant effect between the two tested factors for the rest traits of yield components in the first and/ or second seasons. The highest values of plant height, grains number and weight/ ear were obtained by T.W.C 368 genotype. While, the highest value of ear length was recorded by T.W.C 360 genotype especially when the plant were irrigated every 12 days (normal irrigation). On the other hand, T.W.C 352 genotype produced the lowest values for all abovementioned traits especially under severe stress condition (irrigation every 22 days). In this connection, many researchers recorded a wide range of response to water deficit tolerance in maize genotypes (EL-Hosary et al., 2013; Adebayo & Menkir, 2014; Erdal et al., 2015).

Yields/ fed and translocation indices

The data of yields/ fed, i.e. grain, stover and biological and translocation indices, i.e. crop index (CI) and harvest index (HI) of six tested yellow maize genotypes under different irrigation intervals (12, 17 and 22 days) in 2018 and 2019 seasons are presented in Table 6.

TABLE 6. Yields/ fed and translocation indices of maize genotypes as affected by irrigation intervals and their interaction.

Characters / Treatments		Yields/ fed (ton)						Translocation indices			
		Grain		Stover		Biological		Crop index (%)		Harvest index (%)	
		2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
Irrigation intervals (I)											
I_1		4.252 a	4.075 a	7.213 a	7.112 a	11.465 a	11.187 a	58.95 a	57.30 a	37.09 a	36.43 a
I_2		3.725 b	3.552 b	6.276 b	5.997 b	10.001 b	9.549 b	59.35 a	59.23 a	37.25 a	37.20 a
I_3		3.039 c	2.908 c	5.107 c	5.146 c	8.146 c	8.054 c	59.51 a	56.51 a	37.31 a	36.11 a
Genotypes (G)											
S.C 178		3.668 d	3.586 c	6.331 c	6.179 c	9.999 d	9.765 b	57.94 cd	58.04 ab	36.68 cd	36.72 ab
S.C 176		3.789 c	3.690 b	6.424 c	6.176 c	10.213 c	9.866 b	58.98 bc	59.75 a	37.10 bcd	37.40 a
S.C 168		4.042 a	3.870 a	6.620 b	6.476 b	10.662 b	10.346 a	61.06 a	59.76 a	37.91 a	37.40 a
T.W.C 368		3.964 b	3.793 a	6.944 a	6.828 a	10.908 a	10.621 a	57.09 d	55.55 c	36.34 d	35.71 c
T.W.C 360		3.396 e	3.149 d	5.586 d	5.505 d	8.982 e	8.654 c	60.79 ab	57.23 bc	37.81 ab	36.39 abc
T.W.C 352		3.175 f	2.980 e	5.288 e	5.350 d	8.463 f	8.330 d	60.04 ab	55.71 c	37.52 abc	35.77 bc
Interaction (I x G)											
I_1	S.C 178	4.284 c	4.189 c	7.481 a	7.234 a	11.765 b	11.423 b	57.27 a	57.91 a	36.41 a	35.90 a
	S.C 176	4.400 b	4.337 b	7.547 a	7.468 a	11.947 b	11.805 ab	58.30 a	58.07 a	36.83 a	36.49 a
	S.C 168	4.689 a	4.503 a	7.717 a	7.648 a	12.406 a	12.151 a	60.76 a	58.88 a	37.80 a	36.85 a
	T.W.C 368	4.498 b	4.350 b	7.912 a	7.717 a	12.410 a	12.067 a	56.85 a	56.37 a	36.24 a	35.48 a
	T.W.C 360	3.969 e	3.601 f	6.468 a	6.389 a	10.437 cd	9.990 de	61.36 a	56.36 a	38.03 a	35.76 a
	T.W.C 352	3.673 g	3.469 g	6.154 a	6.216 a	9.827 ef	9.685 e	59.68 a	55.81 a	37.38 a	36.05 a
I_2	S.C 178	3.683 g	3.589 fg	6.529 a	6.036 a	10.212 de	9.625 e	56.41 a	59.46 a	36.07 a	35.47 a
	S.C 176	3.817 f	3.627 f	6.503 a	6.031 a	10.320 d	9.658 e	58.70 a	60.14 a	36.99 a	35.80 a
	S.C 168	4.130 d	3.943 d	6.697 a	6.296 a	10.827 c	10.239 cd	61.67 a	62.63 a	38.15 a	37.06 a
	T.W.C 368	3.968 e	3.800 e	6.892 a	6.873 a	10.860 c	10.673 c	57.57 a	55.29 a	36.54 a	35.54 a
	T.W.C 360	3.500 h	3.307 h	5.609 a	5.420 a	9.109 g	8.727 fg	62.40 a	61.01 a	38.42 a	37.09 a
	T.W.C 352	3.250 ij	3.043 jk	5.424 a	5.324 a	8.674 h	8.367 gh	59.92 a	57.16 a	37.47 a	35.94 a
I_3	S.C 178	3.037 k	2.980 k	4.980 a	5.265 a	8.017 i	8.245 gh	60.98 a	56.60 a	37.88 a	37.44 a
	S.C 176	3.150 jk	3.106 ijk	5.223 a	5.014 a	8.373 hi	8.120 h	60.31 a	61.95 a	37.62 a	37.29 a
	S.C 168	3.305 i	3.165 ij	5.443 a	5.487 a	8.748 gh	8.652 fg	60.72 a	57.68 a	37.78 a	36.77 a
	T.W.C 368	3.425 h	3.229 hi	6.027 a	5.895 a	9.452 f	9.124 f	56.83 a	54.78 a	36.24 a	34.89 a
	T.W.C 360	2.719 l	2.540 l	4.677 a	4.706 a	7.396 j	7.246 i	58.14 a	53.97 a	36.76 a	35.19 a
	T.W.C 352	2.601 m	2.430 l	4.284 a	4.509 a	6.885 k	6.939 i	60.71 a	53.89 a	37.78 a	36.19 a

Irrigation intervals: I_1, I_2 and I_3 = 12, 17 and 22 days, respectively.

The tested irrigation intervals had significant effect of grain, stover and biological yields/ fed, but had insignificant one on translocation indices (CI and HI) in the two seasons. Exposing maize plants to moderate stress (17 days irrigation interval) or severe stress (22 days irrigation interval) caused a gradual reduction in yields/ fed amounted to 12.61 and 28.58 % for grain, 14.33 and 28.42% for stover and 13.70 and 28.47% for biological compared to normal irrigation interval (12 days), respectively, as an average of two seasons. This reduction in the potential yields obtained by the drought stress condition may be due to the harmful effect on vegetative growth traits (Table 3), photosynthetic pigment (Table 4) and yield components (Table 5) as previously discussed. Similar results were founded by other investigators who found that grain and biological productivity were decreased when the maize plants were grown under drought stress condition either by prolonging irrigation intervals (Gomaa et al., 2015; El- Sobky & Desoky, 2017; Solieman et al., 2019) or by holding an irrigation at growth stage (El-Sobky & El-Naggar, 2017; Yasin et al., 2017).

The tested maize genotypes significantly differed in their yields/ fed (grain, stover and biological) as well as translocation indices (crop and harvest indices) over both seasons. As an average of the two seasons, it can be found that S.C 168 genotype produced the highest values of grain yield (3.956 ton/ fed), crop index (60.41%) and harvest index (39.56%). This means that the grain yielding of S.C 168 genotype had more ability to transport enough photosynthetic assimilates from the source (vegetative organs) to the sink (fruiting organs, i.e. grains) than the other tested genotypes. However, the highest values of stover yield (6.886ton/ fed) and biological yield (10.764ton/ fed) were registered by T.W.C 368 genotype. This is to be expected since such genotype recorded the highest values of stem and total dry weight/ plant as recorded in Table 3. These results were coincided by those obtained by Ali (2016), Balbaa & Awad (2018), Darwich (2018) and Mostafa (2018) who reported that yellow maize genotype namely S.C 168 was superior to other tested genotypes in grain yield/ fed.

The interaction effect between the irrigation intervals and maize genotypes was found to be significant for grain and biological yields/ fed in both seasons. The tested maize genotypes were significantly differed in their behavior under various irrigation treatments. Under normal irrigation (I_1) and moderate drought stress (I_2), the highest significant values of grain yield/ fed (4.596 and 4.036 ton/ fed) were obtained by S.C 168 genotype, respectively, while under severe drought stress (I_3), the maximum values of grain yield/ fed (3.327ton/ fed) were recorded by T.W.C 368 genotype, as an average of the two seasons. On the other hand, T.W.C 352 genotype produced the lowest values either under normal (3.571ton/ fed) or moderate (3.147ton/ fed) and severe drought condition (2.516ton/ fed), as an average of both seasons. The inferiority of T.W.C 352 genotype in grain yield/ fed under all experienced irrigation treatments may be due to the decrease in its yield components (no. of ears/ plant, no. of grains/ ear and grain weight/ ear) as previously discussed in Table 5. Concerning the biological yield/ fed, plants of S.C 168 and T.W.C 368 genotypes which were irrigated every 12 days produced the greatest biological yield during both seasons without significant differences between them, while the lowest ones were recorded by the plants of T.W.C 352 which were grown under severe drought stress in the two seasons. On the other hand, the values of stover yield/ fed as well as the translocation indices (crop and harvest indices) were not statistically significant in both seasons indicating that the tested genotypes were similarly responded to different tested irrigation intervals and each factor of them independently acted from the other for these traits.

Grain quality

The data of grain quality characters studied (protein and oil percentages and yields/ fed) of the tested six maize genotypes as influenced by irrigation intervals in the two seasons are presented in Table 7. The values of the percentage and yield for each protein and oil were significantly increased when the plants were exposed to normal irrigation (every 12 days) and then the values were significantly and gradually decreased by prolonging the irrigation intervals to 17 days (moderate water stress) and 22 days (severe water stress) in the two seasons. From these results, it can be concluded that well watering supply may be led to an increase in the nutrient intake, photosynthetic pigments, dry matter accumulation and consequently increased the chemical constituents in maize grains such as protein and oil content. Other investigators found that also the highest significant increase in protein and oil percentage in maize grain were obtained by irrigation every 10 days and then the values were decreased with increasing the irrigation intervals up to 15 days (Abo El-Ezz & Haffez, 2019) or 18 days (Ibrahim & Kandil, 2007). The tested maize genotypes significantly differed in their protein content (protein percentage and yield/ fed) in the two seasons. S.C 168 and T.W.C 368 genotypes had the highest significant values of protein percentage (9.83 and 9.79%), respectively without significant differences among them. However, S.C 168 produced the highest significant values of protein yield/ fed (389.01kg/ fed) compared to the rest maize genotypes, as an average of both seasons. Reversely, the lowest values of protein % (9.11%) and protein yield/ fed (280.62kg/ fed) were obtained by T.W.C 352 genotype as an average of the two seasons. The increment of protein content accrued in grains of S.C 168 may be due to the increase in its dry matter accumulation (table 3), transportation of assimilates (Table 4), grain weight/ ear (Table 5) and grain yield/ fed (Table 6). Moreover, there are significant differences among the tested genotypes in their oil yield/ fed in favor of S.C 176, S.C 168 and T.W.C 368 genotypes without any significant differences among them. However, no significant variations were detected in oil % among all tested genotypes in both seasons. The differences among some yellow maize genotypes were also previously reported by many investigators such as Balbaa & Awad (2018) and Mostafa (2018) for protein percentage as well as Mreer & Mohamad (2017) for oil yield/ unit area.

The interaction between the tested genotypes and irrigation intervals was significant for protein percent and yield/ fed in the second season. However, the values of oil percent and yield/ fed were not significantly affected by the such interaction in both seasons. Moreover, it can be noticed that S.C 168 genotype under normal irrigation (irrigation every 12 days) or moderate stress condition (irrigation every 17 days) and T.W.C 368 genotype under severe stress condition (irrigation every 22 days) surpassed the other tested genotypes at each condition in protein percentage and yield/ fed. However, T.W.C 352 genotype had the lowest values of such traits at the three experienced irrigation intervals treatments.

Drought tolerance indices

The data in Table 8 show that the values of TOL, RYR % and DSI were obviously increased with increasing irrigation intervals from 17 (I_2) to 22 days (I_3) for each tested maize genotype in the two seasons. This means that a large injury and high depression in grain yield of tested maize genotype were recorded when their plants were exposed to severe drought stress condition as compared with normal irrigation system. In comparison among the tested maize genotypes, it can be noticed that genotypes namely T.W.C 360, T.W.C 352 and S.C 168 and S.C 368 had DSI values less than 1 amounted to 0.779, 0.928, 0.950 and 0.953, respectively (as an average of both seasons) when they were irrigated every 17 days. This means that these genotypes can be considered to be relatively drought tolerant because they exhibited smaller values of yield reduction (RYR %) and tolerance index (TOL) under moderate drought stress condition compared to the other tested genotypes under well-watered condition (irrigation every 12 days). On the other hand, S.C 176 and S.C 178 genotypes had DSI values more than 1 (1.155 and 1.123, respectively over the two seasons), indicating that those genotypes were relatively drought sensitive under moderate drought stress condition compared to the other tested genotypes. Reversely, under severe drought stress condition (irrigation every 22 days, "I_3"), genotype T.W.C 368 only was relatively drought tolerant where it had DSI values less than 1. However, the rest genotypes were drought susceptible, where they had DSI values more than 1 and high relative yield reduction. These results are coincided by other investigators, i.e., Abdelghany et al. (2016), Ali (2016), Habliza & Abdelhalim (2017) and Gabr et al. (2018) who reported that the genotypes showing DSI values less than 1 are found to be more tolerant to drought stress while those had DSI values more than 1 are sensitive to drought stress.

TABLE 7. Grain quality of maize genotypes as affected by irrigation intervals and their interaction.

Treatments \ Characters		Protein content % 2018	Protein content % 2019	Protein content Yield (kg/ fed) 2018	Protein content Yield (kg/ fed) 2019	Oil content % 2018	Oil content % 2019	Oil content Yield (kg/ fed) 2018	Oil content Yield (kg/ fed) 2019
Irrigation intervals (I)									
I_1		9.96 a	9.76 a	423.50 a	397.72 a	4.84 a	4.73 a	205.80 a	192.75 a
I_2		9.64 b	9.52 b	359.09 b	338.15 b	4.64 ab	4.52 b	172.84 b	160.55 b
I_3		8.94 c	8.97 c	271.69 c	260.85 c	4.31 b	4.39 b	130.98 c	127.66 c
Genotypes (G)									
S.C 178		9.52 b	9.36 b	349.19 c	335.65 c	4.61 a	4.56 a	169.09 b	163.52 b
S.C 176		9.35 bc	9.16 cd	354.27 c	338.00 c	4.89 a	4.90 a	185.28 a	180.81 a
S.C 168		9.77 a	9.90 a	394.90 a	383.13 a	4.81 a	4.61 a	194.42 a	178.41 a
T.W.C 368		9.74 a	9.85 a	386.09 b	373.61 b	4.62 a	4.53 a	183.14 a	171.82 ab
T.W.C 360		9.46 b	9.23 bc	321.26 d	290.65 d	4.25 a	4.30 a	144.33 c	135.41 c
T.W.C 352		9.23 c	9.00 d	293.05 e	268.20 e	4.40 a	4.39 a	139.70 c	130.82 c
Interaction (I_X G)									
I_1	S.C 178	9.93 a	9.73 d	425.40 a	407.59 c	4.89 a	4.73 a	209.49 a	198.14 a
	S.C 176	9.84 a	9.38 ef	432.96 a	406.81 c	5.22 a	5.08 a	229.68 a	220.32 a
	S.C 168	10.24 a	10.41 a	480.15 a	468.76 a	5.08 a	4.87 a	238.20 a	219.30 a
	T.W.C 368	10.10 a	10.23 b	454.30 a	445.01 b	4.78 a	4.68 a	215.00 a	203.58 a
	T.W.C 360	9.96 a	9.51 e	395.31 a	342.46 f	4.42 a	4.51 a	175.43 a	162.41 a
	T.W.C 352	9.67 a	9.33 ef	355.18 a	323.66 g	4.64 a	4.59 a	170.43 a	159.23 a
I_2	S.C 178	9.61 a	9.39 ef	353.94 a	337.01 f	4.58 a	4.58 a	168.68 a	164.38 a
	S.C 176	9.49 a	9.43 e	362.23 a	342.03 f	4.92 a	4.88 a	187.80 a	177.00 a
	S.C 168	9.91 a	9.93 c	409.28 a	391.54 d	4.89 a	4.54 a	201.96 a	179.01 a
	T.W.C 368	9.78 a	9.81 cd	388.07 a	372.78 e	4.66 a	4.50 a	184.91 a	171.00 a
	T.W.C 360	9.63 a	9.37 ef	337.05 a	309.87 h	4.29 a	4.29 a	150.15 a	141.87 a
	T.W.C 352	9.40 a	9.21 f	305.50 a	280.26 i	4.48 a	4.35 a	145.60 a	132.37 a
I_3	S.C 178	9.00 a	8.97 g	273.33 a	267.31 i	4.35 a	4.40 a	132.11 a	131.12 a
	S.C 176	8.72 a	8.68 h	274.68 a	269.60 i	4.52 a	4.76 a	142.38 a	147.85 a
	S.C 168	9.17 a	9.38 ef	303.07 a	296.88 h	4.46 a	4.45 a	147.40 a	140.84 a
	T.W.C 368	9.35 a	9.52 e	320.24 a	307.40 h	4.41 a	4.43 a	151.04 a	143.04 a
	T.W.C 360	8.78 a	8.82 gh	238.73 a	224.03 j	4.03 a	4.13 a	109.58 a	104.90 a
	T.W.C 352	8.62 a	8.47 i	224.21 a	205.82 k	4.08 a	4.23 a	106.12 a	102.79 a

Irrigation intervals: I_1, I_2 and I_3 = 12, 17 and 22 days, respectively.

TABLE 8. Drought tolerance indices (TOL, RYR % and DSI) of maize genotypes under irrigation intervals during 2018 and 2019 seasons.

Genotypes	Grain yield/ fed (ton)			TOL		RYR %		DSI	
	I_1	I_2	I_3	I_2	I_3	I_2	I_3	I_2	I_3
2018 season									
S.C 178	4.284	3.683	3.037	0.601	1.247	14.03	29.11	1.131	1.021
S.C 176	4.400	3.817	3.150	0.583	1.250	13.25	28.41	1.033	1.005
S.C 168	4.689	4.130	3.305	0.559	1.384	11.92	29.52	0.930	1.044
T.W.C 368	4.498	3.968	3.425	0.530	1.073	11.78	23.86	0.919	0.844
T.W.C 360	3.969	3.500	2.719	0.469	1.250	11.82	31.49	0.921	1.114
T.W.C 352	3.673	3.250	2.601	0.423	1.072	11.52	29.19	0.898	1.033
2019 season									
S.C 178	4.189	3.589	2.980	0.600	1.209	14.32	28.86	1.115	1.008
S.C 176	4.337	3.627	3.106	0.710	1.231	16.37	28.38	1.277	1.004
S.C 168	4.503	3.943	3.165	0.560	1.338	12.44	29.71	0.970	1.051
T.W.C 368	4.350	3.800	3.229	0.550	1.121	12.64	25.77	0.986	0.912
T.W.C 360	3.601	3.307	2.540	0.294	1.061	8.16	29.46	0.637	1.043
T.W.C 352	3.469	3.043	2.430	0.426	1.039	12.28	29.95	0.958	1.060
Averages of the two seasons									
S.C 178	4.237	3.636	3.009	0.601	1.228	14.18	28.99	1.123	1.015
S.C 176	4.369	3.722	3.128	0.647	1.241	14.81	28.40	1.155	1.005
S.C 168	4.596	4.037	3.235	0.560	1.361	12.18	29.62	0.950	1.048
T.W.C 368	4.424	3.884	3.327	0.540	1.097	12.21	24.82	0.953	0.878
T.W.C 360	3.785	3.404	2.630	0.382	1.156	9.99	30.48	0.779	1.079
T.W.C 352	3.571	3.147	2.516	0.425	1.056	11.90	29.57	0.928	1.047

TOL= Tolerance index, RYR %= Relative yield reduction % and DSI= Drought susceptibility index.
Irrigation intervals: I_1, I_2 and I_3= 12, 17 and 22 days, respectively

Conclusion

Finally, it can be concluded that most growth characters, yield and its components studied were negatively affected by water deficit. However, the best tested yellow maize genotypes for drought tolerance were S.C 168 and T.W.C 360 and 352 (under moderate stress) as well as T.W.C 368 genotype (under either moderate or severe drought stress) owing to they had less grain yield reduction and DSI values (less than 1) as compared with the other tested genotypes at Menoufia governorate condition.

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تأثير فترات الري على نمو وانتاجية وجودة بعض التراكيب الوراثية للذرة الشامية الصفراء

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أجريت تجربتان حقليتان بمزرعة كلية الزراعة جامعة المنوفية بشبين الكوم، مصر خلال موسمي الزراعة 2018 و2019 وذلك لدراسة تأثير ثلاث فترات ري وهي الري كل 12 يوم (الفترة العادية)، 17 يوم (الفترة المتوسطة)، 22 يوم (الفترة المتباعدة) على نمو وانتاجية وجودة ست تراكيب وراثية من الذرة الشامية الصفراء: ثلاث هجن فردية (ه.ف 178، ه.ف 176، ه.ف 168) وثلاث هجن ثلاثية (ه.ث 368، ه.ث 360، ه.ث 352) ويمكن تلخيص أهم النتائج المتحصل عليها كالتالي:

- أدت زيادة فترات ري نباتات الذرة من 12 يوم إلى 17 و 22 يوم إلي نقص معنوي حاد في صفات النمو (عدد الأوراق علي النبات، مساحة الأوراق على النبات ووزن الأوراق والسيقان والوزن الكلي الجاف للنبات) وفي الصفات الفسيولوجية (نسبة الكلوروفيل، محتوى الماء النسبي في الورقة) وفي صفات المحصول ومكوناته (طول النبات، طول وقطر الكوز، عدد ووزن الحبوب في الكوز، وزن 100 حبة) وفي صفات محصول الفدان (محصول الفدان والقش والبيولوجي) وفي صفات الجودة في الحبوب (النسبة المئوية للبروتين والزيت، محصول الفدان للزيت والبروتين) في حين ازدادت نسبة البرولين في الأوراق زيادة معنوية واضحة وذلك عند تعرض نباتات الذرة الشامية لفترة الري المتباعدة، هذا ولم تتأثر صفات عدد الكيزان على النبات ودليل المحصول ودليل الحصاد معنويا بفترات الري المختبرة خلال موسمي الزراعة.

- تفوق الهجين الفردي 168 علي بقية الأصناف الأخرى المختبرة في صفات مساحة الأوراق على النبات ووزن الأوراق الجاف ومحصول حبوب الفدان والنسبة المئوية لدليل المحصول والحصاد ومحصول البروتين للفدان أما الهجين الثلاثي 368 فقد تفوق تفوقا معنويا في صفات الوزن الجاف للسيقان والكلي للنبات وطول النبات وعدد الحبوب للكوز ووزن 100 حبة وقطر الكوز ومحصول الفدان لكل من القش والبيولوجي. هذا وقد اعطى الهجين الفردى 168 والهجين الثلاثي 368 أعلى القيم لصفات محتوى الماء النسبي في الورقة وعدد الكيزان ووزن حبوب الكوز ونسبة البروتين ومحصول الزيت للفدان بدون وجود أي اختلافات معنوية بين الصنفين، بينما سجل كل من الهجين الثلاثي 352 و360 أعلي القيم المعنوية لصفتي محتوى البرولين في الأوراق وعدد الأوراق على النبات على الترتيب خلال موسمي الزراعة.

- أعطى كل من الهجين الفردى 168 والهجن الثلاثية 360 و352 (تحت فترات الري المتوسطة) وكذلك الهجين الثلاثي 368 (تحت كل من فترات الري المتوسطة والمتباعدة) أقل القيم لمعدل النقص النسبي لمحصول حبوب الفدان وكذلك أقل القيم لدليل حساسية الجفاف (أقل من 1) مما يشير إلي أن تلك التراكيب الوراثية تتحمل الجفاف نسبيا وذلك مقارنة بباقي الأصناف الأخرى المختبرة تحت ظروف هذه التجربة في محافظة المنوفية.