J.Soil Sci. and Agric. Eng., Mansoura Univ., Vol. 7(11):865 - 872, 2016

Response of Maize (*Zea mays L.*) to Moisture Stress under Different Nitrogen Fertilization Levels

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ABSTRACT

Two field experiments were conducted at Farm of Sids Agricultural Research Station, Egypt, during 2013 and 2014 seasons to study the effect of different irrigation regimes (I_1 = 100 %, I_2 = 85 % and I_3 = 70 % from irrigation requirements) and nitrogen levels (90, 120 and 150 kg N fed^{-1}) on maize growth, yield and its yield attributes and some crop-water relationships. The most important results could be summarized as follows:Irrigated maize plants with full irrigation produced higher values of plant height, ear diameter, 100- grain weight, weight of grains ear^{-1} and grain yield as well as total amount of irrigation water applied, seasonal consumptive use and the net income. Irrigated maize plants with 80 % from irrigation requirements gave the highest values of water use efficiency and utilization efficiency.Supplied maize plants with 150 kg N fed^{-1} induced highest values of the abovementioned growth, yield and its attributes and net income as well as improve seasonal consumptive use, water use efficiency and utilization efficiency.Irrigated maize plants with full irrigation requirements and supplied with 150 kg N fed^{-1} produced highest yield and net income of maize plants.

Keywords: Maize yield, yield components, irrigation requirements, nitrogen fertilization levels and crop - water relations.

INTRODUCTION

The rapid inclination of population growth worldwide in general and in the developing countries in particular forces to increase food production and expansion of agricultural lands (Elias *et al*, 2014). In contrary to the water need for irrigation of agricultural land for enhancing crop production, there is an increasing demand for limited water resource for municipality, industries and for natural resource rehabilitation. Moreover, agriculture is the highest water consuming sector worldwide (Biswas 1997, Abu-Zied, 1999 and Pereira 2006).

Maize (*Zea mays* L.) is one of the most important crop worldwide after rice and wheat because of its high grain and forage yields and the cultivated area of maize in 2013 was 703,921 hectares with average productivity equals 7.72 ton/ha under surface irrigation (Zohry and Ouda, 2015 and Abdullah *et al*, 2015). Maize growth and yield are most sensitive to nitrogen application under moisture stress condition. Improper fertilizer and water management are the two major factors adversely affecting maize growth and productivity under dry land condition. The main objective in agriculture production, so far, focused mostly on the increasing of yield and production (Ulusoy, 2001 and Amanullah *et al*, 2014).

Efficient water management under moisture stress could enhance the crop productivity in the coming decades (Yudelman 1994). Poor water availability and high temperatures result significant stress during critical phases of maize development (Al-Kaisi *et al*, 2013). Payero *et al*. (2006) reported that deficit irrigation of maize distributed over the entire crop growing season might not always result in increasing crop water productivity. They added that maize yield due to deficit irrigation at 50% and 75% levels as compared to the full irrigation would highlight the issues of irrigation water management in the regions with limiting water supply. Karam *et al*. (2007) showed that with increasing drought stress grain yield and its components decreased. Water use efficiency is an important crop index used to assess how soil water is used efficiently for total biomass and grain yield production (Daniel *et al*, 2011). Elias *et al*, 2014 reported that moisture stress applied at some growth stages enhance water use efficiency of maize without significantly reducing the yield. Abdullah *et al*. (2015) stated that maize growth and net income decreased with decreasing in the amount of irrigation. Sani *et al.* (2008) reported that water use and water use efficiency for maize were the highest with application of full consumptive use requirement at each growth stage. Masoero *et al*. (2013) found that the total amount of irrigation water was 494 mm under full irrigation. In Egypt, Yousri (2014) reported that the amount of applied water for maize under full irrigation was 8143.0 m^3/ha. He added that the full irrigation regime improved maize yield, stem diameter, grain weight and 1000-grain weight. In connection, Khalil and Mohamed (2006) found that applying full irrigation significantly increased maize grain yield and yield components. In maize, the reduction in grain yield caused by drought ranges from 10 to 76% depending on the severity of the drought and the growth stage at which it occurs (Bolaoos *et al*, 1993). Payero *et al.* (2006) stated that deficit irrigation at any crop growth stage of the maize crop led to decrease grain yields, and deficit irrigation that spanned across two or more growth stages affect grain production drastically.

The low fertility status of most tropical soils hindered maize production as maize has strong exhausting effect on the soil. It was generally observed that maize fail to produce good grain in plots without adequate nutrients (Adediran and Banjoko, 2003). Therefore, the supply of nitrogen is important for crop maize production as much as water. On the other hand, indiscriminate use of nitrogen leads to increase in production costs and environmental contamination (Gurpreet *et al*, 2013). Inorganic nitrogen fertilizer exert strong influence on plant growth, development and yield (Stefano *et al*, 2004). The availability of sufficient nutrients from inorganic fertilizers lead to improved all activities, enhanced cell multiplication and enlargement and luxuriant growth (Fashina *et al*, 2002). Luxuriant growth resulting from nitrogen fertilizer application leads to larger dry matter production (Obi *et al*, 2005), owing better utilization of solar radiation and more nutrient (Saced *et al*, 2001). In Egypt, many workers such as Ismail *et al*. (1999), Ismail *et al*. (2006), Sadik *et al*. (2009), Ali *et al*. (2012) and Abd El-Hafeez *et al*. (2013) stated that increasing nitrogen levels were significantly increased growth yield and its components of maize. Moreover, Matusso (2016). Reported that increases of N fertilizer level led to increase of yield and yield components. Dawadi and Sah (2012) found that 100 -grain weight, grain weight/ear, and plant height increases with increasing nitrogen levels.

Conditions of water and nitrogen stress lead to reductions in crop production by reducing resource capture and resource use efficiency. It has been reported that maize grown under conditions of limited water supply requires less nitrogen to achieve the maximum grain yield than that required with well water supply (Moser *et al*, 2006). Meysam and Sarangi (2013) reported that maximum grain yield and biomass were observed for full irrigation and full nitrogen treatments.

The main objective of this study are to investigate the effect of different levels of irrigation water and nitrogen fertilization on maize growth and yield and its components as well as some water-crop relations.

MATERIALS AND METHODS

Experiment setup:

The present research trials were conducted during 2013 and 2014 summer seasons at the Experiment Farm of Sids Agricultural Research Station, Beni Swief Governorate (Middle Egypt, Lat. 29º 04' N, Long. 31º 06' E and 30.40 m above the mean sea level). Some physiochemical properties and soil-moisture constants of the experimental site, determined according to Page *et al*. (1982) and Klute (1986) are listed in Tables 1 and 2.

Table 1. Soil particle size distribution and some chemical properties of the experimental site in 2013 and 2014 season.

Seasons	Particle size distribution* Clay	Silt %	Sand	Textural class	Chemical properties** O.M. (%)	EC dSm^{-1} (1:5)	Available (ppm) N	P	K	pH (1:2.5)
2013	50.20	33.45	16.35	clay	1.55	0.55	34.00	18.20	213.90	7.85
2014	50.18	32.47	17.35		1.70	0.60	32.80	19.75	224.31	7.90

Table 2. Some soil water constants and bulk density of the experimental site.

Seasons	Soil Depth (cm)	Field capacity (%, w/w)*	Wilting point (%, w/w)*	Available water (%, w/w)*	Bulk density (gc m^{-3})*
2013	00 – 15	45.08	21.58	23.50	1.13
	15 – 30	37.95	18.04	19.91	1.24
	30 – 45	35.95	17.32	18.63	1.28
	45 – 60	33.14	16.04	17.10	1.32
Mean		38.03	18.25	19.79	1.27
2014	00 – 15	44.56	22.17	22.39	1.17
	15 – 30	37.09	17.66	19.43	1.29
	30 – 45	35.55	16.92	18.63	1.35
	45 – 60	33.19	15.80	17.39	1.37
Mean		37.60	18.14	19.46	1.30

*** According to Klute (1986) **according to Page *et al*. (1982)**

The treatments were laid out in a split-plot experimental design with four replicates. Deficit irrigation treatments were allocated at the main plots, while the assessed nitrogen fertilizer in the form of ammonium sulphate (20.5%) levels were occupied the sub-plots as follows:

Main plots (Irrigation levels, I):

I_1 = 100% Irrigation requirements (Full Irrigation), I_2 = 85% from irrigation requirements and I_3 = 70% from irrigation requirements (the irrigation treatments were started after the life irrigation).

Sub plots (Nitrogen fertilization rates, N):

N_1 = 90 kg N fed^{-1}, N_2 = 120 kg N fed^{-1} and N_3 = 150 kg N fed^{-1}

Maize grains of Single- Cross 10 at the rate of 15 kg fed^{-1}. were sown on 20 and 25 of May and harvested on 23 and 25 of September in 2013 and 2014 seasons, respectively.

Fertilization was carried out according to the recommendation of the Ministry of Agriculture in Egypt as follow: superphosphate and potassium sulphate were applied with equipment of soil for planting at rates 30 kg P_2O_5 and 48 kg K_2O fed^{-1}, respectively. The other usual cultural processes of maize plants were practiced. At harvesting time ten plants were chosen randomly from the two inner rows of each sub-plot and following data were measured: Plant height (cm), ear diameter (cm), grain weight ear^{-1} (g), 100- grain weight (g) and grain yield (kg fed^{-1}). The quantity of applied irrigation water was measured using flow-meter attached to the irrigation pump.

Data collected for the studied variables were subjected to statistical analysis using M-Stat computer package to calculate F ratio according to (Senedecor and Cochran, 1980). The means were compared using Least Significant Difference (LSD) at 5% level according to Waller and Duncan 1969.

Water relations:

Water consumptive use (CU):

To determining water consumptive use, soil samples were taken using a regular auger just before and 48 hours after each irrigation and at harvest time in 15 cm depth from soil surface down to 60 cm of soil profile. Water consumptive use was calculated according to Israelsen and Hansen (1962) as follows:

$$CU = \frac{(Q_2 - Q_1)}{100} \times D \times Bd$$

Where:

CU = Water consumptive use, cm

Q_2 = Soil layer moisture content, wt/wt %, 48 hours after irrigation.

Q_1 = Soil layer moisture content, wt/wt %, Just before irrigation.

D = Effective root zone, 60 cm.

Bd = Bulk density of soil layer, g cm^{-3}

Water consumptive use as (m^3 fed^{-1}) was obtained by multiplying the value of WCU (m) by 4200 m^2 .

Water use efficiency (WUE):

WUE of a crop is a function of multiple factors, including physiological characteristics of maize, genotype, and soil characteristics, meteorological conditions, and agronomic practices. Water use efficiency in kg m^{-3} was estimated for each treatment according to the equation described by Vites (1965) as follow:

WUE (kg m^{-3}) = Grain yield (kg fed^{-1}) / Consumptive use (m^3 fed^{-1})

Water utilization efficiency (WUtE):

Water utilization efficiency (WUtE) values were calculated according to Jensen (1983) as follow:

WUtE (kg m^{-3}) = Grain yield (kg fed^{-1}) / Applied irrigation water (m^3 fed^{-1}) Applied irrigation water was recorded by a flow meter installed in the main unit of irrigation water.

Economical evaluation :

Economic evaluation aims to study the economic evaluation of the experimental treatments. This study will be done through calculation of the differences between costs of production (L.E. fed^{-1}) and incomes profits (L.E. fed^{-1}) to obtain the net return (L.E. fed^{-1}) of treatments, will be determine the best treatments that achieved the highest financial return (L.E. fed^{-1}). All costs of production and incomes profits were mathematically changed to be per feddan. On the other hand, incomes profits were calculated from the actually prices of average maize production per ton fed^{-1} equal 2300 L.E. (Economic Bulletin of Ministry of Agric., Egypt issued in, 2013). The total production costs are calculated as follow:

- Irrespective of irrigation and fertilizer cost, the other cultural practices cost about 2080 L.E. fed^{-1}.
- The cost of irrigation treatments were: 413.33, 351.33 and 289.33 L.E. fed^{-1} for I_1, I_2 and I_3 respectively.
- The costs nitrogen fertilization are calculated as 6.83 L.E. for one kilogram nitrogen.

RESULTS AND DISCUSSION

Growth and yield components:-

The measured plant height, ear diameter, 100 - grain weight and grain weight ear^{-1} were significantly affected due to the adopted irrigation treatments, (Table 3). The highest values of the abovementioned growth and yield attributes were recorded with full irrigation (I_1), which increased by 8.08, 3.86, 2.01 and 5.56; and 15.61, 6.53, 18.89 and 12.55% comparable with those irrigated under I_2 and I_3 treatments in the first season, respectively. Such findings are in parallel with those of Khalil and Mohamed (2006) who found that applying full irrigation practice significantly increased grain yield components for maize. Moreover, Ghooshchi *et al*. (2008) found that water stress before silking, at silking or grain filling growth stages caused a significant reduction in grains No cob-1 and 1000- grain weight comparing with normal irrigation.

Table 3. Plant height, ear diameter, 100 grain weight, grain weight ear^{-1} and grain yield as affected by irrigation, N-fertilizer rates and their interaction in 2013 and 2014 seasons.

Irrigation	Plant height (cm)				Ear diameter (cm)				100-grain weight (g)				Grain weight ear^{-1} (g)				Grain yield (kg fed^{-1})			
	N-fertilizer (2013 season)																			
	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean
I_1	261.5	268.0	281.5	270.3	4.35	4.60	4.75	4.57	31.77	33.08	34.09	32.98	279.3	323.9	354.3	319.2	2931	3334	3799	3355
I_2	235.5	247.8	267.0	250.1	4.10	4.45	4.65	4.40	30.96	32.79	33.23	32.33	271.8	304.8	330.5	302.4	2654	3074	3457	3062
I_3	214.8	228.3	258.5	233.8	4.05	4.30	4.50	4.29	26.93	27.46	28.83	27.74	254.2	291.3	305.2	283.6	2148	2507	3058	2571
Mean	237.3	248.0	269.0	251.4	4.17	4.45	4.63	4.42	29.87	31.11	32.05	31.02	268.4	306.7	330.0	301.7	2578	2972	3438	2996
	L.S.D at 0.05																			
Irrigation	7.42				0.16				0.91				38.39				287.2			
Nitrogen	7.48				0.10				1.52				18.71				201.4			
Interaction	12.97				0.18				2.63				32.42				349.1			
	(2014 season)																			
I_1	252.0	277.8	291.8	273.8	4.40	4.65	4.70	4.58	31.36	34.6	35.16	33.71	287.6	336.9	372.0	332.2	3068	3488	3981	3512
I_2	224.3	253.8	281.0	253.0	4.20	4.55	4.60	4.45	31.10	33.78	34.84	33.24	277.2	313.9	339.2	310.1	2813	3177	3662	3217
I_3	222.8	243.3	250.8	238.9	4.15	4.20	4.40	4.25	27.70	29.36	30.10	29.06	256.7	297.1	314.4	289.4	2296	2681	3105	2694
Mean	233.0	258.3	274.5	255.2	4.25	4.47	4.57	4.43	30.05	32.58	33.45	32.03	273.8	316.0	341.9	310.6	2726	3115	3583	3141
	L.S.D at 0.05																			
Irrigation	20.20				0.22				2.66				41.02				214.3			
Nitrogen	14.33				0.17				0.87				19.87				215.1			
Interaction	24.85				0.30				1.52				34.43				372.6			

(I_1, I_2 and I_3) irrigation treatments : 100, 85 and 70 % from irrigation requirements ; (N_1, N_2 and N_3) nitrogen fertilizer: 90, 120 and 150 kg N fed^{-1}, respectively

Concerning growth and yield attributes (plant height, ear diameter, 100 -grain weight and grain weight ear^{-1}) as affected by nitrogen levels, results in Table (3) reveal that the highest values of the investigated growth and yield attributes were recorded with N_3 in 1st and 2nd seasons.

The relative increasing caused by N_3 treatment compared to N_1 and N_2 for the abovementioned parameters reached to 13.4, 11.0, 7.3, and 23.0; and 8.5, 4.0, 3.0 and 7.6 % in the first season, respectively. The corresponding increasing in the second season were 17.8, 7.5, 11.3, and 24.9; and 6.3, 2.2, 2.7 and 8.2 % in the same respect.

These increment due to increasing nitrogen level is mainly explained to nitrogen is the most important nutrient for plant growth which caused cell developed, then tended be large and function of protoplasm, which consequently increased both growth and yield attributes of plants. These results agree with those obtained by Ismail *et al*. (2006) and Dawadi and Sah (2012).

The highest values of the studied characters were attained due to interaction of irrigation (100%) and nitrogen level (N_3), and such finding was true in 1stand 2ndseasons. These results are in agreement with Meysam and Sarangi (2013)

Grain yield (kg fed^{-1}):

The results in Table (3) showed that maize grain yield was significantly affected by irrigation and nitrogen treatments in 2013 and 2014. The data indicated that increasing water amounts resulted in a relatively higher yield, since water deficit was main yield-limiting factor in both years. The maximum yield was obtained at full irrigation (I_1) and the minimum yield at 70% from irrigation requirements (I_3) in 2013 and 2014 seasons. The grain yield under irrigation treatments (full Irrigation I_1, 85% I_2 and 70% from irrigation requirements I_3) were 3355, 3026, 2571 and 3512, 3217, 2694 kg fed^{-1} in 2013 and 2014, respectively. The highest grain yield values were recorded with 100%, which exceeded than the other irrigation treatments. The percent increases in grain yield under I_1 was 9.6, 30.5% and 9.2, 30.4% in 1stand 2nd seasons when compared with I_2 and I_3 treatments, respectively. The increment in grain yield under sufficiently irrigation can be attributed to the adequate turgidity which must have prevailed inside the plant thereby helping in significantly better shoot development, number of leaves per plant and then higher grain yield. Such findings are in parallel with those reported by El-Tantawy *et al*. (2007), Jat *et al*. (2008), Payero *et al*. (2006), Khalil and Mohamed (2006) and Gurpreet *et al*. (2013) who found that applying full irrigation practice significantly increased grain yield of maize. Moreover, Traore *et al*. (2000) stated that water stress can affect growth, development and physiological processes of corn plants, which can reduce biomass and ultimately grain yield.

The highest main values of grain yield 3438 and 3583 kg fed^{-1} in both seasons, respectively were obtained under N_3 (150 kg N fed^{-1}). Comparing with those obtained under N_1 (90 kg N fed^{-1}) and N_2 (120 kg N fed^{-1}). The primitive effect of the high nitrogen fertilization on maize grain yield could be explained by the fact that maize plant responded to great extent to N-fertilization because its nature as a heavy N feeder crop, as well as the deficit in soil – N (Genaidy *et al*, 1992). These results are in harmony with those obtained by Abd El-Hafeez *et al*. (2013) and Matusso (2016).

Results in Table (3) show that maize grain yields significantly affected by the interaction between nitrogen rates and irrigation treatments. Applying 150 kg N fed^{-1} and full irrigation gave the highest grain yield, i.e., 3799 and 3981 kg fed^{-1} for both growing seasons, respectively.

Irrigation water applied (IWA, m^3 fed^{-1}):

Data in Table (4) show the amount of irrigation water applied. Planting and second irrigation watering through complete emergence was accompanied with amount of (480 and 490 m^3 fed^{-1}) and (365 and 368 m^3 fed^{-1}) in the first and second seasons, respectively for all treatments. The values of water applied were increased under 100% of full irrigation treatment (I_1) in comparison with the other two treatments of 85 and 70% from irrigation requirements (I_2 and I_3).

Table 4. Number of irrigation and applied water (m^3 fed^{-1}) for each irrigation under different irrigation treatments during the 2013 and 2014 seasons.

Treatments	I_1		I_2		I_3	
	Seasons					
Irrigation event	First	Second	First	Second	First	Second
Planting irrigation	480	490	480	490	480	490
Second	365	368	365	368	365	368
Third	390	395	332	336	273	277
Fourth	405	410	344	349	284	287
Fifth	415	425	353	361	291	298
Sixth	400	415	340	353	280	291
Seventh	395	405	336	344	277	284
Eighth	370	375	315	319	259	263
Ninth	305	307	359	261	214	215
Total (m^3 fed^{-1})	3525	3590	3124	3181	2723	2773

(I_1, I_2 and I_3) irrigation treatments : 100, 85 and 70 % from irrigation requirements

The highest values were 3525 and 3590 m^3 fed^{-1} due to (I_1) treatment. While, the lowest values were recorded under (I_3) treatment as 2723 and 2773 m^3 fed^{-1} due to in the two growing seasons, respectively. The data revealed that 70% from irrigation requirements (I_3) could saved about 22.75 and 22.76% of applied water, compared with full irrigation (I_1) in the 1st and the 2nd seasons, respectively. In addition, under 85% from irrigation requirements (I_2) the same trend was noticed with reduction percentages values reached about 11.38 and 11.39%, as compared with (I_1). This is logic and expected result and it is attributable to more irrigation events applied under full irrigation, similar results were obtained by Ouda *et al.* (2009), Masoero *et al.* (2013), Yousri (2014) and Khalil and Mohamed (2006) they stated that applying full irrigation practice significantly increased grain yield.

Water consumptive use (Cu, m^3 fed^{-1}):

Average CU values as affected by irrigation treatments on maize crop in the two growing seasons are presented in Table (5). Data presented indicated that the water consumption was of maize crop as the percentage of water added increased i.e. 100, 85 and 70%, respectively. Data in Table 5 indicated that full irrigation gave higher amount of the average CU values of 2820 and 2872 m^3 fed^{-1}, in 2013 and 2014, respectively. On the other hand, irrigation with 85 and 70% from irrigation requirements reduced average CU values to 2217, 2355 and 1970, 2043 m^3 fed^{-1} in 2013 and 2014 respectively. The high water consumptive use for the full irrigation treatment is due to the abundance of soil moisture in the soil and the plants tend to grow without stress in the last stage of growth and hence use more water. These results may be attributed to the amount of irrigation increased and the soil moisture was more available for extraction by plant roots. These results agree with those obtained by Rayan *et al*. (1999) and Moussa and Abdel-Maksoud (2004) In connection, Oktem *et al*. (2003), Ayotamuno *et al*. (2007) and Abd El-Latif *et al*. (2016) reported that the increment in water consumption by plants depended on availability of soil moisture in the root zone and plant growth stage.

Table 5. Seasonal water applied (IWA, m^3 fed^{-1}), seasonal consumptive use (CU, m^3 fed^{-1}), water use efficiency (WUE, kg m^{-3} consumed) and water utilization efficiency (WUtE, kg m^{-3} applied) as affected by irrigation treatments in 2013 and 2014 seasons.

Irrigation treatments	Nitrogen Level	2013 IWA	2013 CU	2013 Grain	2013 WUE	2013 WUtE	2014 IWA	2014 CU	2014 Grain	2014 WUE	2014 WUtE
I_1	N_1	3525	2620	2931	1.12	0.83	3590	2675	3068	1.15	0.85
	N_2		2790	3334	1.19	0.95		2810	3488	1.24	0.97
	N_3		3050	3799	1.25	1.08		3130	3981	1.27	1.11
Mean			2820	3355	1.19	0.95		2872	3512	1.22	0.98
I_2	N_1	3124	2140	2654	1.24	0.85	3181	2210	2813	1.27	0.88
	N_2		2175	3074	1.41	0.98		2325	3177	1.37	1.00
	N_3		2335	3457	1.48	1.11		2530	3662	1.45	1.15
Mean			2217	3062	1.38	0.98		2355	3217	1.36	1.01
I_3	N_1	2723	1860	2148	1.15	0.79	2773	1925	2296	1.19	0.83
	N_2		1925	2507	1.30	0.92		2030	2681	1.32	0.97
	N_3		2125	3058	1.44	1.12		2175	3105	1.43	1.12
Mean			1970	2571	1.30	0.94		2043	2694	1.32	0.97
Mean of N fertilizer	N_1	3124	2207	2578	1.17	0.82	3181	2270	2726	1.20	0.86
	N_2		2297	2972	1.30	0.95		2388	3115	1.31	0.98
	N_3		2503	3438	1.39	1.10		2612	3583	1.38	1.13

(I_1, I_2 and I_3) irrigation treatments : 100, 85 and 70 % from irrigation requirements ; (N_1, N_2 and N_3) nitrogen fertilizer: 90, 120 and 150 kg N fed^{-1}, respectively

As for nitrogen treatments, the results clearly show that the water consumptive use values were positively responded to nitrogen levels. Fertilized maize plants with 150 kg N fed^{-1} gave CU values higher than those supplied with 90 or 120 kg N fed^{-1} by about 13.4 and 9.0 % in the first season, respectively. Similar trends were obtained in the second season. These results is mostly due to the plants fertilized with 150 kg N fed^{-1} exerted higher root and shoot growth, consequently consumed more water.

As for the interaction between water and nitrogen treatments, the data, reveal that the plants irrigated with full irrigation requirements and received 150 kg N fed^{-1} recorded the highest CU values in both seasons. On the other hand the plants watered with 80 % from it requirements and fertilized with 90 kg N fed^{-1} showed the lowest CU values.

Water Use Efficiency (WUE, kg m^{-3}):

The water use efficiency or the productivity of maize grains kg m^{-3} obtained from each cubic meter water consumed in both seasons is recorded in Table (5). WUE was different based on the treatments and years. WUE values ranged between 1.12 and 1.48 kg m^{-3} for the both years. The maximum values of WUE were obtained from the 85% treatment (1.38 and 1.36 kg m^3, respectively). Oktem *et al*. (2003) reported that WUE range of 1.04 - 1.36 kg m^{-3}. However, the range of WUE obtained in this study was higher than those reported by Igbadun *et al*. (2008) and Pandey *et al*. (2000). Generally, WUE are influenced by crop yield potential, irrigation treatments and climatic characteristics of the region. The results related to the efficiencies shows that when irrigation water is limited, 25% deficit irrigation can be applied for increase the water use efficiencies. The present results are in line with those reported by Ghadiri and Majidian (2003), Elias *et al*. (2014), Abdel Mawly and Zanouny (2005), Yang *et al*. (2005) and El-Atawy (2007) who mentioned that the efficiency of water use had decreased as the soil moisture was maintained high by the frequent irrigation.

Regarding nitrogen fertilization, the data show that water use efficiency was increased as nitrogen levels increased. The values of WUE under 150 kg N fed^{-1} surpassed that under 90 and 120 kg N fed^{-1} by about 18.8 and 6.9 % in the first season, respectively. The corresponding increasing in the second season were 15.0 and 5.3 % in the same respect.

Data in Table (5) indicate that maize plants watered with 70 % from irrigation requirements and fertilized with high nitrogen level, i.e. 150 kg N fed^{-1}

had a high values of water use efficiency in both seasons, while the lowest one was produced for plants irrigated with full irrigation requirements and fertilized with 90 kg N fed^{-1} . Mansouri *et al*. (2010) reported that irrigation water can be conserved and yields maintained in maize plant (as sensitive crop to drought stress) under water limited conditions through improved fertilizer managements.

Water utilization efficiency (WUtE, kg m^{-3}):

Efficiency water utilization is an important limiting factor to crop production. Water utilization efficiency (WUtE) values for maize yield as affected by the tested variables during 2013 and 2014 growing season are presented in Table (5). Results showed that average water utilization efficiency (WUtE) values were affected by irrigation treatments and nitrogen level treatments. The obtained results in Table (5) indicate that the average water utilization efficiency (WUtE) as affected by irrigation treatments in the two seasons, were 0.95, 0.98 and 0.94 kg m^{-3} under 100, 85 and 70% from irrigation requirements, respectively in the first season. The corresponding value for the second season were 0.98, 1.01 and 0.97 kg grain m^{-3}.

The results obtained show that WUtE was positively responded to increasing nitrogen level up to 150 kg N fed-1 which mainly due to the effect of nitrogen on improving the growth of roots and shoots of maize in turn improved water absorption from soil.

The data for the interaction show that the maximum value of WUtE were 1.11 and 1.15 kg grain m^{-3} water applied in 2013 and 2014 seasons, respectively. It was obtained from I_2 irrigation treatment and N_3 nitrogen fertilizer treatment. While, the lowest value of WUtE was 0.79 and 0.83 kg m^{-3} water applied, was obtained by I_3 irrigation treatment and N_1 nitrogen fertilizer in 2013 and 2014 seasons, respectively.

Net return :

Total cost, gross return and net return of maize as affected by different irrigation treatments are presented in Table (6).

Table 6. Economic analysis as affected by different irrigation and nitrogen treatments (average yield of 2 years)

Treatments		IWA m^3 fed^{-1}	Yield kg fed^{-1}	Total production cost (L.E. fed^{-1})	Income	Net return
I_1	N_1	3558	3000	3108	6900	3792
	N_2		3411	3313	7845	4532
	N_3		3890	3518	8947	5429
Mean			3434	3313	7897	4584
I_2	N_1	3153	2734	3046	6288	3242
	N_2		3126	3251	7190	3939
	N_3		3560	3456	8188	4732
Mean			3140	3251	7222	3971
I_3	N_1	2748	2222	2984	5111	2127
	N_2		2594	3189	5966	2777
	N_3		3082	3394	7089	3695
Mean			2633	3189	6055	2866
Mean of N fertilizer	N_1	3153	2652	3046	6100	3054
	N_2		3044	3251	7000	3749
	N_3		3511	3456	8075	4619

(I_1, I_2 and I_3) irrigation treatments : 100, 85 and 70 % from irrigation requirements ; (N_1, N_2 and N_3) nitrogen fertilizer: 90, 120 and 150 kg N fed^{-1}, respectively.

The total cost of production increased with increasing both nitrogen and irrigation levels. The results revealed that the full irrigation and increasing nitrogen fertilizer (I_1 N_3) is the best choice for higher yield (3890 kg fed^{-1}) and net income (5429 L.E. fed^{-1}) under the study. The present results are in line with reported by Pandey *et al*. (2000), who mentioned that the use of full irrigation water management and nutrient application is essential to maximize crop production and returns for the farmers.

CONCLUTION

It could be recommended to irrigated maize plants with 100% from irrigation requirements and fertilized with 150 kg N fed^{-1} for high production and net income.

REFERENCES

Abdullah, K.; K. Hayrettin; Ö. Mehmet and B. Gamze (2015). The Effect of different irrigation water levels on grain yield, yield components and some quality parameters of silage maize (Zea mays indentata Sturt.) in Marmara Region of Turkey. Not Bot Horti Agrobo, (1):138-145.

Abd El-Hafeez, A.M.; H.A. Awadalla and S.A. Ismail (2013). Influence of different sources and levels of nitrogen and rock phosphate addition on maize productivity and soil fertility. J. Soil Sci. and Agric Eng., Mansoura Univ., 4(11):1313-1328.

Abd El-Latif, K.M., M.A. Mahmoud, M.M. Ewis and M.F.I. El-Akram (2016). Effect of skipping the last irrigation on the productivity and some water relations of four maize hybrids under Middle Egypt conditions. 1st International Conference on Applied Microbiology-March 1-3, Giza, Egypt,:163-178.

Abdel Mawly, S.E. and I. Zanouny (2005). Irrigation and fertilization management for maximizing crop-water efficiencies of maize. Minia. J. Agric. Res. & Develop., Egypt, 25(1): 125-146.

Abu-Zied, M. (1999). Egypt's Water Policy for the 21 Century, 7 Nile Conference, March 15-19, Cairo, Egypt.

Adediran, J.A. and V.A. Banjoko (2003). Comparative effectiveness of some compost fertilizer formulations for maize in Nigeria. Nig. J. Soil Sci., 13:42-48.

Ali, M.E.; S.A. Ismail; A.H. El-Hameid; O.H.M. El-Hussieny and F.H. El-Sheref-Ghada (2012). Effect of natural fertilizers under different levels of nitrogen and farmyard manure on productivity of maize. Fayoum J. Agric. Res. & Dev., 26(1):49-63.

Al-Kaisi, M.M.; R.W. Elmore; J.G. Guzman; H.M. Hanna; C.E. Hart; M.J. Helmers; E.W. Hodgson; A.W. Lenssen; A.P. Mallarino; A.E. Robertson and J.E. Sawyer (2013). Drought impact on crop production and the soil environment: 2012 experiences from Iowa. Journal of Soil & Water Conservation,68:19-24.

Amanullah; Khair M. K.; K. Azam; K. Imran; S. Zahir and Z. Hussain (2014). Growth and yield response of maize (*Zea mays* L.) to foliar NPK-fertilizers under moisture stress condition. Soil Environ. 33(2): 116-123.

Ayotamuno, J.M.; K. Zuofa; O. A. Sunday and R. B. Kogbara (2007). Response of maize and cucumber intercrop to soil moisture control through irrigation and mulching during the dry season in Nigeria. African Journal of Biotechnology, 6 (5): 509-515.

Biswas, Asit K. (1997). Water Development and Environmental Resources. Environmental Planning, Management, and Development. A. K. Biswas, eds. TATA McGRAW. HILL.

Bulletin Ministry Agric., Egypt Economic Issu. (2013). Estimated average cost of production for field crops.

Bolaoos, J.; G.O. Edmeades and L. Martinetz (1993). Eight cycles of selection for drought tolerance in lowland tropical maize. III. Response in drought adaptive physiological and morphological traits. Field Crops Res.31:269-86.

Daniel, K.A.; O.F. Justice; O.A. Emmanuel and M.A. Harry (2011). Water use efficiencies of maize cultivars grown under rain-fed conditions. Agricultural Sciences, 2 (2): 125-130.

Dawadi, D.R. and S.K. Sah (2012). Growth and yield of hybrid maize (*Zea mays* L.) in relation to planting density and nitrogen levels during winter season in Nepal. Tropical Agricultural Research, 23 (3): 218 – 227.

El-Atawy, E.E.I. (2007). Irrigation and fertilization management under the conditions of Kafr El-Sheikh Governorate soil. Ph.D. Thesis, Soil Dept. Fac. of Agric., Mansoura Univ., Egypt.

El-Tantawy, M.M.; S. A. Ouda and F.A. Khalil (2007). Irrigation scheduling for maize crop grown under middle Egypt conditions. Res. J. Agric. and Biol. Sci., 3 : 456-62.

Elias, M.; M. Mulugeta and H. Tilahun (2014). Response of maize (*Zea mays* L.) for moisture stress condition at different growth stages. International Journal of Recent Research in Life Sciences, 1 (1): 12-21.

Fashina, A. S.; K. A. Olatunji and K. O. Alasiri (2002). Effects of different plant population and poultry manure on yield of Ugu (*Telfairia occidentalis*) in Lagos State, Nigeria in Proceedings of the annual Conference of Horticultural Society of Nigeria (HORTON), pp. 123-127.

Genaidy, S.; M. Sobh; M. Hegazy and A.R. Ahmed (1992). Nitrogen and phosphorus fertilizers requirement and time of application to maize (*Zea mays* L.). Egypt J. Agric. Res., 70(2): 339-351.

Ghadiri, H. and M. Majidian (2003). Effect of different nitrogen fertilizer levels and moisture stress during milky and dough stages on grain yield, yield components and water use efficiency of corn (*Zea mays* L.). Journal of Science and Technology of Agriculture and Natural resources, 7(2): 103-113.

Ghooshchi, F.; M. Seilsepour and P. Jafari (2008). Effects of water stress on yield and some agronomic traits of maize [SC 301]. American-Eurasian J. Agric. & Environ. Sci., 4 (3): 302-305.

Gurpreet, S.A.; K.V. Krishan and S.S. Maha (2013). Effect of different irrigation regimes and nitrogen levels on growth parameters and yield of late kharif sown maize (Zea mays L.). Crop Res. 45 (1, 2 & 3) : 96-105.

Igbadun, H.E.; B.A. Salim; A.K.P.R. Tarimo and H.F. Mahoo (2008). Effects of deficit irrigation scheduling on yields and soil water balance of irrigated maize. Irrig. Sci., 27:11–23.

Ismail, S.A.; M.A.Morsy; S.S. Awad and F.S. Salem (1999). Effect of some maize varieties, nitrogen fertilization levels and zinc application on grain and stalk, yields, total N and Zn uptake and protein content. Fayoum J. Agric., Res. & Dev., 13(1): 57-68.

Ismail, S.A.; M.A. Morsy; A.A. Omran and M.M. Foaad (2006). The productivity of some hybrids (*Zea mays* L.) grown in an alluvial soil under different nitrogen sources and levels. The Second Conference on Farm Integrated Pest Management. Fac. of Agric. Fayum Univ., 16-18 January, Egypt.

Israelsen, O.W. and V.E. Hansen (1962). Irrigation Principles and Practices, 3rd edit. John Wiley and Sons, Inc., New York, USA.

Jat, M. L.; S.S. Pal; R. Singh; D. Singh and M.S. Gill (2008). Effect of moisture regimes and nitrogen management options on crop and water productivity and nitrogen-use efficiency in maize (Zea mays)-wheat (Triticum aestivium) cropping systems. Indian J. agric. Sci., 78 : 881-83.

Jensen, M.E. (1983). Design and operation of farm irrigation systems. Am. Soc. Ag. Eng. Mitchigan, USA. pp. 827.

Karam, F.; R. Masaad; T. Sfeir; O. Mounzer and Y. Rouphael (2007). Evapotranspiration and seed yield of field grown soybean under deficit irrigation conditions. Agr. Water Manag. 75: 226-244.

Khalil, F.A.F. and S.G.A. Mohamed (2006). Studies on the inter-relationship among irrigation and maize varieties on yield and water relations using some statistical procedures. Anal. Agric. Sci., Moshtohor. 44(1):393-406.

Klute, A. (1986). Methods of Soil Analysis. 2nd ed. Part 1: Physical and Mineralogical Methods. American Society of Agronomys Madison, Wisconsin, USA.

Mansouri-F.C.; S. A.M.M. Sanavy and S.F. Saberali (2010). Maize yield response to deficit irrigation during low-sensitive growth stages and nitrogen rate under semi-arid climatic conditions. Agric. Water Manage., 97 : 12-22.

Masoero, F.; A. Gallo; G. Giuberti; L. Fiorentini and M. Moschini (2013). Effect of water-saving irrigation regime on whole-plant yield and nutritive value of maize hybrids. J Sci. Food Agric.; 93: 3040–3045.

Matusso, J.M.M. (2016). Growth and yield response of maize (*Zea mays* L.) to different nitrogen levels in acid soils. Academic Research Journal of Agricultural Science and Research, 4(2): 35-44.

Meysam, A. and A. Sarangi (2013). Deficit irrigation and nitrogen effects on maize growth in semi arid environment. World Applied Sciences Journal, 21 (11): 1687-1692.

Moser, S.B.; B. Feil; S. Jampatong and P. Stamp 2006). Effects of pre-anthesis drought, nitrogen fertilizer rate and variety on grain yield, yield components and harvest index of tropical maize. Agric. Water Manage. 81 : 41-58.

Moussa, A.M. and H.H. Abdel-Maksoud (2004). Effect of soil moisture regime on yield and its components and water use efficiency for some wheat cultivars. Annals Agric. Sci., Ain Shams Univ., 49 (2): 982-986.

Obi, C. O.; P. C. Nnabude and E. Onucha (2005). Effects of kitchen waste compost and tillage on soil chemical properties and yield of Okra (*Abelmuschus esculentus*), Soil Sci., 15:69-76.

Oktem, A.; A. Simsek and A.G. Oktem (2003). Deficit irrigation effects on sweet corn (Zea mays sccharata Sturt) with drip irrigation system in a semi-arid region. Water-yield relationship. Agric. Water Manage., 61: 63-74.

Ouda, S.A.; R. Abou ELenin and M.A. Sheif (2009). Determination of water productivity of maize yield under deficit irrigation in Middle Egypt. The African J.Plant Sci. Biotechnol.,3(1):80-85.

Page, A.L.; R.H. Miller and D.R. Keeny (1982). Methods of Soil Analysis. Part II. Chemical and Microbiological Properties 2nd ed. Amer. Soc. Agron. Inc. Soil Sci. Sco. Amer. Inc. Madison, Wisconsin, USA.

Pandey, R.K.; J.W. Maranville and A. Admou (2000). Deficit irrigation and nitrogen effects on maize in Sahelian environment. II. Shoot growth. Agricultural Water Management, 46(1):1-13.

Payero, J.O.; S.R. Melvin; S. Irmak and D. Tarkalson (2006). Yield response of corn to deficit irrigation in an semiarid climate. Agricultural Water Management. 84: 101-112.

Pereira, L.S. (2006). Irrigated Agriculture: Facing Environmental and Water Scarcity Challenges. International Symposium on Water and Land management for sustainable Irrigated Agriculture, Cukurova University April 4-8, Turkey.

Rayan, A.A.; S.M. El-Marsafawy and K.A. Mohamed (1999). Response of wheat varieties to different sowing dates and irrigation regimes in Upper Egypt. 3rd Conf. on Farm Irrigation and Agroclimatology, Giza Paper No. 44.

Saced, I.M.; R. Abbasi; and M. Kazim (2004). Response of maize (Zea mays) to nitrogen and phosphorus fertilization under agro-climatic condition of Rawalokl. Azad Jammu and Kaslim and Kashmir, Pak. J. Biological Sci., 4:949-952.

Sadik, M.K.; S.A. Ismail; O.H.M. El-Hussieny and R.F. Hashem (2009). Influence of levels and methods of some organic and inorganic fertilizatiers application on maize: 1- Growth and nutrients uptake. J. Agric. Sci., Mansoura Univ., 34(7): 9001-9014.

Sani, B.M.; K. O. Oluwasemire and H.I. Mohammed (2008). Effect of irrigation and plant density on the growth, yield and water use efficiency of early maize in the Nigerian savanna. ARPN Journal of Agricultural and Biological Science (2): 33-40.

Snedecor, G.W. and W.G. Cochran (1980). Statistical Methods 7th Ed. Iowa State Univ. Press, Iowa, U.S.A.

Stefano, P.; R. Dris and F. Rapparini (2004). Influence of growing conditions and yield and quality of cherry. II. Fruit. J. Agric. And Env., 2:307-309.

Traore, S.B.; R.E. Carlson; C.D. Pilcher and M.E. Rice (2000). Bt and non- Bt maize growth and development as affected by temperature and drought stress. Agron. J., 92:1027–1035.

Ulusoy, E. (2001). Objectives of agricultural techniques in changing conditions and conceptions in 2000 years. In 20 National Agricultural Mechanization Congress. Sanliurfa, Turkey.

Vites, F.G. (1965). Increasing water use efficiency by soil management in plant environment and efficient water use. J. American Soc. Agronomy, 26: 537-546

Waller, R.A. and C.B. Duncan (1969). Abays rule for symmetric multiple comparison problem Amer. State Assoc. Jour. December: 1485-1503.

Yang, T.; Z.S. Liang; J. Xue and S. Kang (2005). Diversity of water use efficiency in various maize varieties. Transaction of the Chinese Society of Agricultural Engineering. 21(10): 21-25.

Yousri, I.M.A. (2014). Improving Growth, Yield and Water Productivity of Some Maize Cultivars by New Planting Method. Innovative Water Management Award winning.

Yudelman, M. (1994). Feeding the world. International Irrigation Management Institute Review 8: 4-15.

Zohry, A.A. and S.A. Ouda (2015). Facing Water Scarcity in Egypt by Intercropping: Maximizing Maize Production to Reduce its Gap under Changing Climate. LAP LAMBERT Academic publishing. IS: 978-3-659-80628-5.

استجابة الذرة الشامية للإجهاد الرطوبى تحت مستويات مختلفة من التسميد النتروجينى

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أقيمت تجربتان حقليتان خلال موسم2013 ، 2014 بمحطة البحوث الزراعية بسدس – بنى سويف بهدف دراسة تأثير معاملات الري والتسميد النتروجينى على المحصول ومكوناته وبعض العلاقات المائية ، وكانت معاملات الرى هى 100% ، 85% ، 70% من الاحتياجات المائية وثلاث مستويات من التسميد النتروجينى (90 ، 120 ، 150 كجم نيتروجين للفدان). وكانت أهم النتائج ما يلي:-أدت معاملة الري الكامل 100% من الاحتياجات المائية لنبات الذرة إلى زيادة في طول النبات وقطر الكوز ووزن الـ 100 حبة ووزن حبوب الكوز ومحصول الحبوب للفدان وكذلك الكميه الكلية لمياه الري المضافة والاستهلاك المائي وصافى الدخل.سجلت معاملة الري 85% من الاحتياجات المائية أعلى قيم لكفاءة استعمال واستخدام المياه مقارنتا بمعاملة 100% ، 70 % من الاحتياجات المائية في كلا من الموسمين.أدى تسميد نبات الذرة بمعدل 150 كجم نيتروجين للفدان إلى أعلى قيم لطول النبات وقطر الكوز ووزن الـ 100 حبه ووزن حبوب الكوز ومحصول الحبوب للفدان وكذلك كفاءة استخدام والاستفادة من المياه وصافى الدخل مقارنتا بالتسميد بمعدل 120 أو 90 كجم نيتروجين للفدان. أدت معاملة الري 100% من الاحتياجات المائية مع التسميد بمعدل 150 كجم نيتروجين للفدان الى تحسين صفات النمو والمحصول ومكوناته لنبات الذرة وكذلك صافى الدخل.من نتائج البحث يمكن التوصية برى الذرة بـ 100% من الاحتياجات المائية مع التسميد بمعدل 150 كجم نيتروجين للفدان للحصول على أعلى إنتاجية وصافى الدخل.