

## Irrigation Schedule with Different Nitrogen Sources and Levels for Maize Productivity and Some Water Relations

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**T**WO FIELD experiments were conducted in two successive summer seasons during 2016 and 2017 at Sids Agricultural Research Station, Beni-Suef Governorate, Egypt. This research was carried out to study irrigation schedule impact using pan evaporation method (Class A pan and irrigation at 0.7, 1.0 and 1.3 pan evaporation coefficient, APE) with different nitrogen sources (ammonia gas, ammonium nitrate and urea) and levels (214 and 286 kg N ha<sup>-1</sup>) on maize yield attributes as well as some water relations, namely, seasonal applied water (AP), seasonal consumptive use (CU), water utilization efficiency (WUtE) and water use efficiency (WUE). Results showed that increasing pan evaporation coefficient from 0.7 up to 1.3 increased maize yield and improved its attributes, N, P and K uptake by grains and/or stover, seasonal applied water and seasonal consumptive use. The differences between the effect of 1.0 and 1.3 of APE on maize grain and stover yields were not significant. Irrigation at 1.0 APE gave the highest WUtE and WUE followed by irrigation at 1.3 APE. Whereas the lowest one produced under 0.7 of APE. Added nitrogen as anhydrous ammonia increased all studied yield and its attributes, N, P and K uptake, seasonal consumptive use, water utilization efficiency and water use efficiency followed by ammonium nitrate, while urea fertilizer exhibited the lowest ones. Increasing nitrogen levels from 214 to 286 Kg ha<sup>-1</sup> improved maize yield and its attributes, N, P and K uptake as well as the studied water relations. The best treatment for maize productivity and water relation is to irrigate at 1.0 of APE with nitrogen addition as ammonia gas at the rate of 286 Kg ha<sup>-1</sup>, while saving about 960 m<sup>3</sup> per hectare with no significant decrease in yield. This study confirms that maize irrigation at different pan evaporation coefficient (0.7, 1.0 and 1.3) with different nitrogen fertilization sources and levels affect maize productivity traits and some water relations.

**Keywords:** Maize attributes, Nitrogen sources and nitrogen levels, Pan coefficient, Water relations.

### Introduction

Water is the most limiting natural resource for agricultural production in arid and semi-arid regions. Nowadays the total annual water resource of Egypt is about 67.27 billion m<sup>3</sup> (Hafiz and Ewis, 2015). The agricultural sector consumes almost 80-90% of the total water allocated to Egypt. Therefore, there is a need for decreasing plant water consumption through using more efficient irrigation methods (Tayel *et al.*, 2007), plant breeding technology, longer irrigation intervals, higher moisture depletion, skipping during the early vegetative growth or during maturation stage, and timing length of irrigation interval with the stage of plant growth (Faki, 1991). Moreover,

Egypt is the 15th most populated country in the world. Its population has tripled during the last 50 years. Egypt receives about 98 per cent of its fresh water from the Nile River originating outside its international border (Zorkany, 2014). The usefulness of evaporation pan to predict soil moisture deficit in field and to estimate the crop water requirement for weekly and long period is discussed in detail by Ashraf *et al.* (2002), Khalil and Mohamed (2006) and Eid *et al.* (2010). El bably (2007) stated that irrigation scheduling of maize at 1.2 of accumulation of pan evaporation significantly increased plant height, ear length, number of rows/ears, number of grains/rows, 100-grain weight and grain yield.

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Nitrogen is an essential nutrient for both maize quantity and quality as it is a component of protein and chlorophyll. It is thus, essential for photosynthesis, vegetative and reproductive growth and it often determines yield of maize (Igbal *et al.*, 2006). Nitrogen for maize cultivation is equally important to realize the yield potential (Sajedi *et al.*, 2009). Among different elements of Egypt soil, nitrogen is the key input for achieving higher yield of maize, but nitrogenous fertilizer may be increased to a certain level and thereafter it has got adverse effect. It was generally observed that maize fail to produce good grains in plots without adequate nutrients. Therefore, the supply of nitrogen is important for 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 exerts strong influence on plant growth, development and yield (Stefano *et al.*, 2004). The availability of sufficient nutrients from inorganic fertilizers lead to improve 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 many investigators stated that increasing nitrogen levels were increased growth, yield and its components, and nutrient uptake of maize (Ismail *et al.*, 1999; Ismail *et al.*, 2006; Sadik *et al.*, 2009; Ali *et al.*, 2012; Abd El-Hafeez *et al.*, 2013, and Wang and Xing, 2017). In general, increases in soil moisture promote the response of maize yield to nitrogen application, especially at high nitrogen rate (Eck, 1984). Also, N uptake was strongly affected by water supply (Martin *et al.*, 1982). Norwood (2000) and El-Sharkawy *et al.* (2006) pointed out that increasing N rate was accompanied with markedly increase in maize grain yield under applied adequate water. In this concern, Eid *et al.* (2010); Azizian and Sepaskhah (2014), and Nilahyana *et al.* (2018) show that nitrogen use efficiency (NUE) increased with decreasing water applied and decreased with increasing N rate.

Maize is one of the most important crops in the world. It is the third major cereal crop after wheat and rice with regard to the world production. However, it is the highest yielding cereal crop known. It is a major feed crop in many countries, because the grains are rich in the energy and its use in the manufacture of many industrial products. Keeping in view, the above said points, field experiments were conducted to examine the interaction irrigation at different pan evaporation coefficient (0.7, 1.0 and 1.3), sources and levels of nitrogen fertilizers on maize productivity and some water relations.

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## Materials and Methods

The present research trials were conducted during 2016 and 2017 summer seasons at the experimental Farm of Sids Agricultural Research Station, Beni-Suef Governorate, Middle Egypt, Lat.29° 04 N, long 31° 06 E and 30-40 m above the mean sea level. Some physico-chemical properties and soil moisture constants of the experimental sites were determined and listed in Tables 1 and 2 (according to Klute, 1986 and Page *et al.* 1982). Some metrological data of the experimental site which were recorded during two growth seasons of maize plants are illustrated in Table 3. The experimental design was split-split plot design in three factors with four replicates. The factors were:

- 1- Irrigation scheduling treatments which carried out using the pan evaporation method (Class A pan), the treatments were irrigation at 1.3 (I<sub>1</sub>), 1.0 (I<sub>2</sub>) and 0.7 (I<sub>3</sub>) pan evaporation coefficient.
- 2- Nitrogen sources, namely, urea (46.5% N, U), ammonium nitrate (33.5% N, AN) and ammonia gas (82% N, AG).
- 3- Nitrogen levels at rate of 214 and 286 N ha<sup>-1</sup>.

The irrigation treatments were allocated in main plots and the nitrogen sources were devolved in sub plot, while nitrogen levels were randomly assigned in sub-sub plots. Urea and ammonium nitrate fertilizers were added at two equal doses before first and second irrigations, while ammonia gas treatments were injected directly into soil (at 14% moisture) at 15 cm depth, 30 cm spacing between points of injection before 7 days from sowing. Grains of maize (*Zea mays* L.) cultivar Single cross 10 were sown in 15th and 20th June in the two seasons, respectively, the experimental plot consisted of five ridges, 4.2 meters in length and 60 cm apart, occupying an area of 12.6 m<sup>2</sup> (about 1/794 hectare). The phosphorus fertilizer was added to all plots as calcium superphosphate (15.5% P<sub>2</sub>O<sub>5</sub>) at rate of 55 kg P<sub>2</sub>O<sub>5</sub>/ha before sowing, while potassium fertilizer was applied as potassium sulphate (48% K<sub>2</sub>O) at rate of 57 kg K<sub>2</sub>O/ha in two equal doses, the first after thinning and the second at one month later. Wheat is the preceding crop. All other agricultural practices were applied as done in the region.

At harvesting ten plants were chosen randomly from the inner rows of each plot to measure maize yield components, i.e., number of rows ear<sup>-1</sup>, number of grains row<sup>-1</sup> and 100 grain weight. Also, grain and stover yields were determined for each plot and converted to t ha<sup>-1</sup>. Representative samples were taken from grains and stover to determine N, P and K concentrations according to AOAC (1990). Then N, P and K uptake in grains and/or stover were calculated.

**TABLE 1. Some soil physicochemical properties of the experimental site in 2016 and 2017 seasons**

Soil properties	2016	2017
Soil particle distribution:		
Particle size distribution:		
Clay (%)	51.11	50.35
Silt (%)	32.36	31.67
Sand (%)	16.53	17.98
Texture grade	Clay	Clay
Chemical properties:		
pH (1:2.5 soil-water suspension)	7.95	8.00
EC, soil paste (dS m <sup>-1</sup> )	1.13	1.23
Organic matter (%)	1.61	1.75
Available N (mg kg)	22.50	23.72
Available P (mg kg)	15.1	17.3
Available K (mg kg)	187	179

**TABLE 2. Some soil moisture constants and bulk density of the experimental site**

Season	Soil depth (cm)	Field Capacity (% w/w)	Wilting Point (% w/w)	Bulk Density (g cm <sup>-3</sup> )	Available Water (w/w %)	
					W%	mm
2016	0.0-15	46.09	22.36	1.162	23.73	41.36
	15-30	35.91	16.15	1.172	19.76	34.74
	30-45	33.78	15.33	1.176	18.45	32.54
	45-60	31.30	14.92	1.181	16.35	27.74
2017	0.0-15	46.31	23.35	1.179	22.96	40.60
	15-30	38.15	18.97	1.253	19.18	36.05
	30-45	35.19	17.52	1.266	17.67	33.56
	45-60	32.51	16.16	1.315	16.36	32.27

**TABLE 3. Some metrological data of the experimental site during both growth seasons of maize plants**

Seasons Intervals	2016					2017				
	Air temperature C		Relative humidity%		E.P mm/day	Air temperature C		Relative humidity%		E.P mm/day
	Max.	Min.	Max.	Man.		Max.	Min.	Max.	Min.	
01-10/6	33.8	21.1	88	21	7.8	34.1	20.4	75	22	8.0
11-20/6	35.7	21.8	88	22	8.0	34.8	20.5	78	23	8.1
21-30/6	37.3	22.0	87	22	8.1	35.2	21.6	79	24	8.3
01-10/7	40.7	24.2	86	23	8.3	38.8	24.5	74	25	8.4
11-20/7	41.2	25.7	87	24	8.5	40.9	26.3	75	27	8.6
21-31/7	43.1	26.3	87	25	8.7	42.1	26.9	76	27	8.7
01-10/8	42.5	24.9	86	26	8.6	41.6	25.2	75	26	8.5
11-20/8	41.1	24.4	86	29	8.4	40.0	24.8	74	26	8.3
21-31/8	40.9	24.0	87	29	8.3	39.6	24.0	77	24	8.0
01-10/9	39.1	23.3	82	27	7.5	38.5	23.8	81	20	7.5
11-20/9	37.2	22.9	80	27	7.3	37.3	22.7	79	21	7.3
21-30/9	34.3	21.1	80	25	7.2	37.0	21.8	79	22	7.1
01-10/10	33.5	19.9	76	21	6.0	33.2	19.8	70	22	6.5
11-20/10	31.6	19.3	77	19	5.8	30.6	19.1	71	21	6.3
21-31/10	30.1	18.7	78	18	5.6	32.3	18.6	75	24	6.0

*Soil and water relationships measurements and calculations**-Time of irrigation*

The available water has been converted to water depth in mm as shown in Table (2), it was 136.38 and 142.48 mm for both growth seasons, respectively. At every irrigation event, the equivalent amount of evaporation that can occur was estimated, meanwhile amount of available soil water is being used. Scheduling of irrigation started after applying the first irrigation. Monthly accumulative pan evaporation (APE), number and irrigation intervals are given in Table (4).

*-Irrigation water applied (WA)*

Irrigation water was calculated by the summation of the daily records of class A pan evaporation.

*Seasonal applied irrigation water*

Submerged flow orifice with fixed dimension was used to measure the amount of water applied according to Michael, 1978 as the following equation.

$$Q = CA\sqrt{2gh}$$

where:

Q = discharge through orifice (L/sec.).

C = coefficient of the discharge (0.61).

A = cross-section area of orifice (cm<sup>2</sup>).

g = acceleration of gravity (980cm/sec<sup>2</sup>).

h = pressure head causing discharge through the orifice (cm).

**TABLE 4. Accumulative pan evaporation (APE) number and irrigation intervals during both growing seasons**

Seasons	2016				2017			
	Interval of APE	APE mm/day	Irrigation at APE of			APE Mm/day	Irrigation at A.P.E of	
0.7 (I <sub>3</sub> ) 194.9mm			1.0 (I <sub>2</sub> ) 136.4mm	1.3 (I <sub>1</sub> ) 104.9mm	0.7 (I <sub>3</sub> ) 203.6mm		1.0 (I <sub>2</sub> ) 142.5mm	1.3 (I <sub>1</sub> ) 109.6mm
1-10/6	7.8				8.0			
11-20/6	8.0		Sowing date 15/6		8.1			
21-30/6	8.1				8.2		Sowing date 20/6	
							11/7 first irrigation (20)	
1-10/7	8.3		6/7 first irrigation (20)		8.3			
11-20/7	8.5	29/7(23)		21/7(16)	8.4			27/7(17)
21-31/7	8.7	17/7(12)			8.6	3/8 (24)		
				29/7(12)		23/7 (13)		
1-10/8	8.6	21/8(23)	6/8(16)		8.2		13/8(17)	
11-20/8	8.4				8.1		31/8(18)	5/8(13)
21-31/8	8.3	14/9(25)	22/8(16)	10/8(12)	8.0	28/8(25)	20/9(20)	29/8(14)
1-10/9	7.5			23/8(13)	7.4			
11-20/9	7.3		8/9(17)		7.2			13/9(15)
21-30/9	7.2			5/9(14)	7.0	25/9(28)		29/9(16)
Total number of irrigations		5	6	7		5	6	7

The figures shown in between brackets indicate the irrigation intervals in days.

**TABLE 4a. Seasonal water applied (m3 ha-1) as affected by irrigation treatments for both seasons**

No of irrigation	Irrigation treatments					
	1.3 APE (I1)		1.0 APE (I2)		0.7 APE (I3)	
	2016	2017	2016	2017	2016	2017
Sowing irrigation	1326	1308	1326	1308	1326	1308
Live irrigation	1040	1015	1040	1015	1040	1015
Third irrigation	1101	1076	1107	1048	1050	1030
Fourth irrigation	1139	1081	1136	1107	1465	1349
Fifth irrigation	1164	1128	1241	1207	1229	1218
Sixth irrigation	1124	1104	1160	1135	-----	-----
Seventh irrigation	1106	1038	-----	-----	-----	-----
Total	8000	7750	7010	6820	6110	5920

**TABLE 4b. Number and irrigation intervals as affected by irrigation treatments**

Irrigation treatments	No. of irrigation	Irrigation intervals, days													
		2016							2017						
1.3 APE (I1)	7	Sowing	20	12	12	12	13	14	Sowing	20	13	13	14	15	16
1.0 APE (I2)	6	Sowing	20	16	16	16	17	---	Sowing	20	17	17	18	20	---
0.7 APE (I3)	5	Sowing	20	23	23	25	---	---	Sowing	20	24	25	28	---	---

*Crop – water relation parameters**- Seasonal consumptive use (CU)*

To determining the crop water consumptive use, soil samples were taken just before irrigation, 48 hours after each irrigation event and at harvest in 15 cm increment system to 60 cm depth of the soil profile. The crop water consumptive use between each two successive irrigation was calculated according to Israelsen and Hansen (1962) as follow:

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

where:

CU = Actual consumptive use (cm).

D = Effective root zone depth (cm), 60 cm.

Bd = Bulk density of depth (g/cm<sup>3</sup>).

Q<sub>2</sub> = Soil moisture percentage (wt/wt) two days after irrigation.

Q<sub>1</sub> = Soil moisture percentage (wt/wt) just before the next irrigation.

The time need for each plot was recorded.

*- Water use efficiency (WUE)*

The water use efficiency as water consumed per kg seed maize/m<sup>3</sup> was calculated for each treatment following the formula described by Vites (1965).

$$WUE (kg/m^3) = \frac{\text{Maize grain yield (kg ha}^{-1}\text{)}}{\text{Consumptive use (m}^3 \text{ ha}^{-1}\text{)}}$$

*- Water utilization efficiency (Water productivity, WP)*

Water productivity is an efficiency term calculated as a ratio of product water output over water input. Water productivity in the present study is expressed as kilogram of maize grain yield per unit of applied irrigation water (FAO, 2003).

$$WP = (kg/m^3) = \frac{\text{Maize grain yield (kg ha}^{-1}\text{)}}{\text{Water applied (m}^3 \text{ ha}^{-1}\text{)}}$$

*Statistical analysis*

The obtained data were statistically analyzed by analysis of variance according to method described by Snedecor and Cochran (1980). Duncan's multiple range for comparing the differences between treatment means was used at the probability level of 0.05.

**Results and Discussion***Yield components*

Data in Table 5 represent the effect of irrigation scheduling, nitrogen sources and levels on yield components of maize. The data indicated that irrigation at 1.3 (I<sub>1</sub>) accumulative evaporation (APE) gave statistically number of rows/ear, number of grains/row and 100-grain weight equal to those under I<sub>2</sub> and higher than I<sub>3</sub>. The reduction of these parameters resulted to decrease moisture content (I<sub>3</sub>) reached to 2.7, 6.2 and 14.6% over (I<sub>2</sub>), respectively in the first season. The corresponding decreasing in the second season were 2.4, 6.1 and 14.5% in the same order. It is obvious to notice that effect of the reduction of moisture content was more pronounced in the weight of grains than the other two yield component parameters. These reductions in yield component parameters may be due to water shortage that causes the close of the stomata and reduce all metabolism process within plant tissues (Eid *et al.*, 2010). Also, Kuchenbuch *et al.* (2006) and Sangakkara *et al.* (2010) mentioned that, the lack of sufficient soil moisture affects growth and development of roots. Similar results were obtained by Galbiatti *et al.* (2004) and El-Tantawy *et al.* (2007) who reported that yield components of maize plants were gradually increased as a result of increasing soil moisture content.

As for different nitrogen sources, the data reveal that all studied maize yield components were significantly affected by nitrogen fertilizer sources. It could be arranged that the effect of nitrogen sources on yield components in descending order as follow: ammonia gas > ammonium nitrate > urea. The superiority of ammonia gas than other two nitrogen fertilizers may due to the promoted effect of anhydrous ammonia on decreasing soil pH caused by injection of anhydrous ammonia which enhanced nutrient uptake. In this connection, Sommer (2005) mentioned that the roots absorbed nitrogen out of there only if they are sufficiently supplied with saccharides from the aboveground parts and plant can thus use nitrogen in metabolism of nitrogenous compounds. The roots that participate in uptake of nitrogen and ammonia from depots, (the injection of liquid ammonia fertilizer into soil in limited points of application creating so-called depots) become denser and branch due to saccharides produced in the aboveground part of plant. Also, roots distribution changes in accordance with plant growth stage and they usually grow from free soil towards depots. These results are in line with those obtained by Ismail et al (1996) and El-Masry et al (2006).

Concerning the nitrogen levels, the data show that, regardless the nitrogen sources, increasing nitrogen levels gradually increased maize yield components. In the first season, added 286 Kg N ha<sup>-1</sup> increased number of rows/ear, number of grains/row and 100-grain weight by about 0.8, 4.7 and 8.09% when compared with 214 kg N ha<sup>-1</sup>,

respectively. Same trends were obtained in the second season. The promotive effect of increasing nitrogen levels on maize yield components is mainly due to merestmic activity, vegetative growth and accumulation of photosynthates resulted by nitrogen (Dubey *et al.*, 2013). These results agree with those obtained by El-Zubair *et al.* (2015) and Jat *et al.* (2017).

#### Grain and stover yields

Data in Fig. (1 and 2) represent the effect of irrigation and nitrogen sources and levels on grain and stover yield of maize. It is evident from the data that irrigation treatments had significantly affected maize yields. It was observed that irrigation at 1.3 APE gave higher grain and stover yields over irrigation at 1.0 and 0.7 APE. The maximum grain and stover yields recorded in irrigation at 1.3 APE were 7.049 and 7.865 t ha<sup>-1</sup> in the first season and 7.112 and 7.938 t ha<sup>-1</sup> in the second one, respectively, followed by that irrigation at 1.0 PAE (6.826 and 7.754 t ha<sup>-1</sup> in the first season and 6.911 and 7.858 t ha<sup>-1</sup> in the second season, respectively, with no significant differences between them. On the other hand, the irrigation at 0.7 PAE yielded the lowest grain and stover yields. The higher grain and stover yields with increasing levels of irrigation might be due to the significant enhancement in yield components as mentioned before and also to the availability of water as an important factor in the plant growth. The reduction in maize yields resulted in decreasing the availability of soil moisture content (I<sub>3</sub> treatment) and could be attributed to water shortage (Eid *et al.*, 2010). These results are similar to those obtained by Shinde *et al.* (2014) and Ewis *et al.* (2016).

TABLE 5. Means of yield components of maize plants as affected by irrigation schedule and nitrogen sources and levels

Treatments	Number of row/ear		Number of grains/row		100-grain weight (g)	
	2016	2017	2016	2017	2016	2017
<b>Irrigation</b>						
I1 (1.3 APE)	12.98 b	13.03 b	45.29 a	45.34 a	30.28 a	29.91 a
I2 (1.0 APE)	13.12 a	13.15 a	44.60 b	44.68 b	29.87 b	29.96 a
I3 (0.7 APE)	12.76 c	12.83 c	41.85 c	41.97 c	25.52 c	25.63 b
<b>N sources</b>						
Urea	12.90 c	12.92 c	43.81 c	43.90 c	28.21 c	28.04 c
A. N.	12.95 b	13.00 b	43.95 b	44.03 b	28.60 b	28.44 b
A. G.	13.01 a	13.09 a	44.04 a	44.11 a	28.96 a	29.02 a
<b>N levels</b>						
214 kg/ha	12.90 b	12.94 b	42.93 b	43.03 b	27.44 b	27.64 b
286 kg/ha	13.00 a	13.05 a	44.93 a	44.99 a	29.66 a	29.42 a

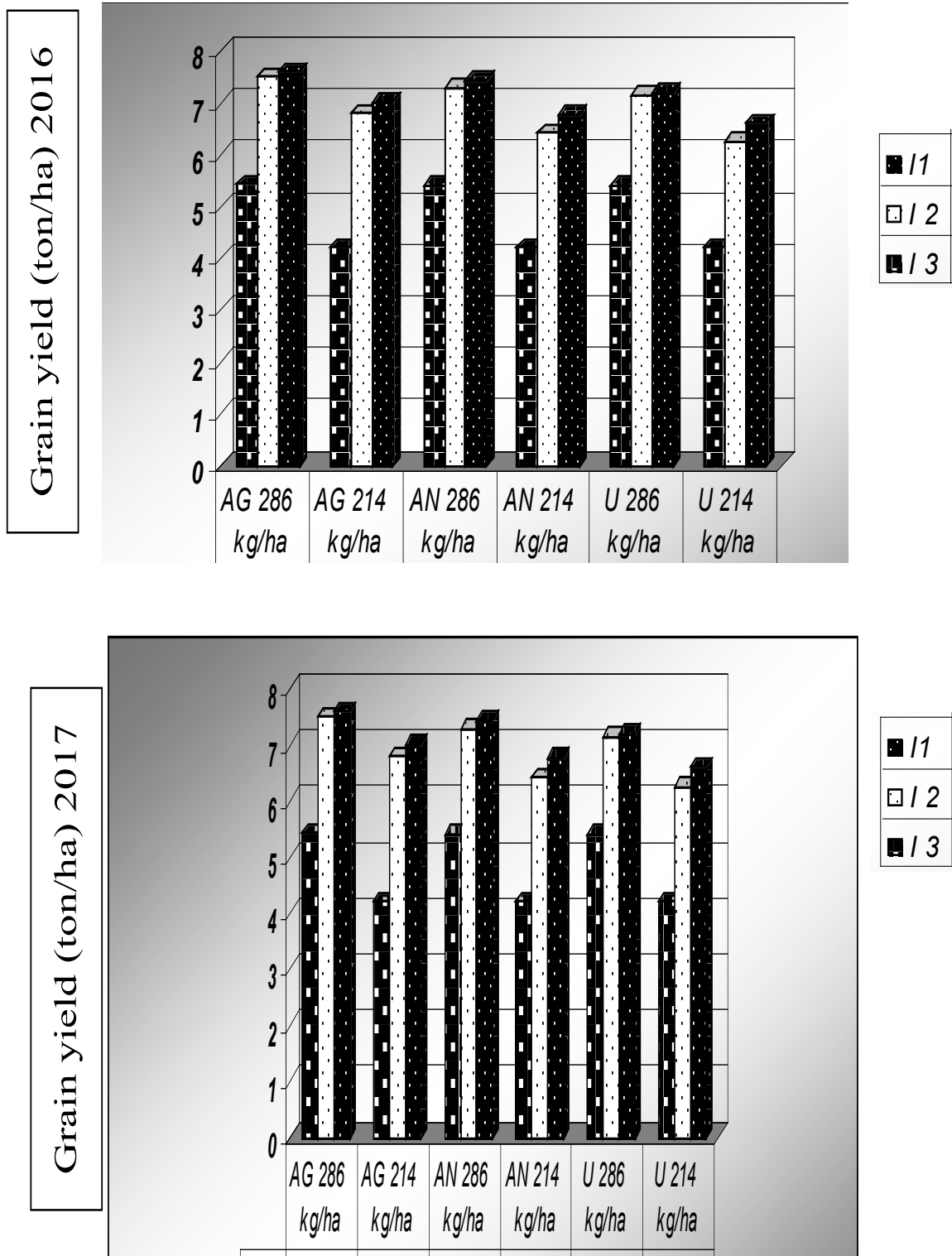


Fig. 1. Means of grain yield of maize plants as affected by irrigation schedule and nitrogen sources and levels

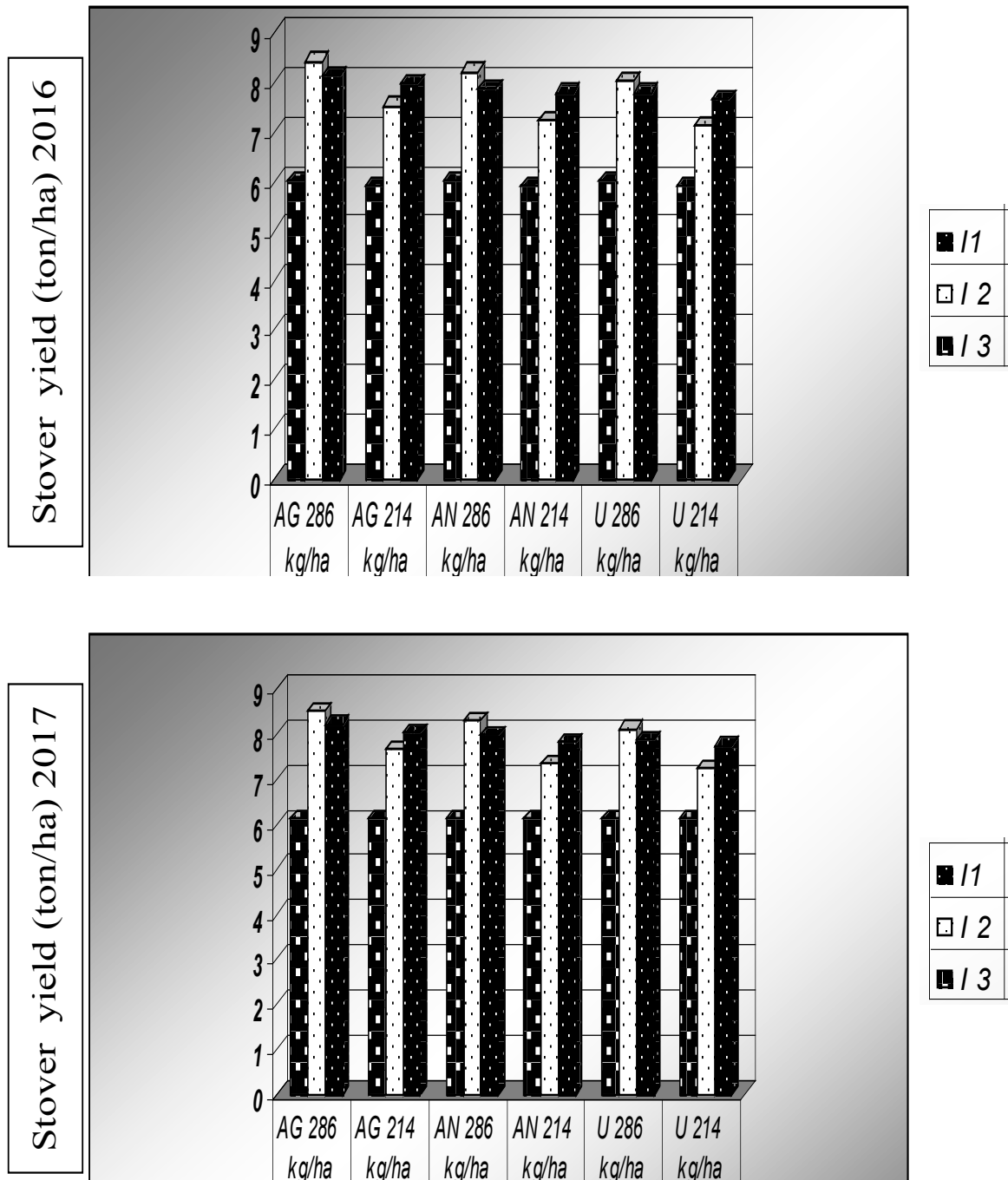


Fig. 2. Means of stover yield of maize plants as affected by irrigation schedule and nitrogen sources and levels



As for nitrogen sources, the data show that both grain and stover yields were significantly affected by nitrogen sources. The effect of nitrogen sources on grain and stover yields could be arranged in the descending order as follows: ammonia gas > ammonium nitrate > urea. The superiority of ammonia gas over ammonium nitrate and urea on maize grain yield reached 2.3 and 8.5% in the first season and 3.1 and 5.1% in the second season, respectively. Similar trends were obtained for stover yields. The superiority of ammonia gas over other two sources can be explained by the improvement in soil chemical conditions and in turn enhanced yield components of maize as discussed before. In this connection Abd El-Kader (2002) mentioned that injection of ammonia caused decreases in soil pH after 36 hours from injection. Similar results were obtained by El-Masry *et al.* (2006) and Ismail *et al.* (2014).

Regarding nitrogen levels, data in Table 6 revealed that increasing nitrogen levels up to 286 kg ha<sup>-1</sup> significantly increased both grain and stover yields in both growing seasons. The application of 286 kg N ha<sup>-1</sup> increased grain yield by about 15.6 and 15.2% over 214 kg N/ha in both seasons, respectively. Stover yield followed the similar pattern as grain yield. The promotive effect of increasing nitrogen levels on grain and stover yields may be due to the exuberant vegetative growth and yield components noted in the case of higher doses of nitrogen application (Shirazi *et al.*, 2011). Similar results were obtained by Al-Kaisi and Yin (2003) and Markovic *et al.* (2017).

#### Nitrogen, P and K uptake

The data regarding nutrient uptake in grains and/or stover as affected by irrigation treatments as well as nitrogen sources and levels are given in Tables 6, 7 and 8. The increase in the available soil moisture significantly increased N, P and K in grains and/or stover. The maximum total N, P and K recorded with irrigation at 1.3 APE were 203.55, 51.60 and 182.05 kg ha<sup>-1</sup> in the first season and 206.45, 52.73 and 181.23 kg ha<sup>-1</sup> in the second one, respectively. Whereas, minimum total of 126.29, 30.23 and 106.48 kg N, P and K ha<sup>-1</sup> in the first season and 127.34, 31.42 and 110.30 kg N, P and K in the second season, respectively were up taken by maize plants under I<sub>3</sub> (deficient available moisture). It can be explained that more frequent irrigation Events increase lability of nutrients, enhance nutrients diffusion as cross section area for diffusion increases and tortuosity of path is decreased (Rahim *et al.*, 2010). These results are similar to those obtained by Al-Kaisi and Yin (2003) and Zorkany (2014).

Data for nitrogen sources showed that N and K uptake only were significantly affected by nitrogen sources, which ammonia gas recorded the highest values, followed by ammonium nitrate. Whereas, urea exerted the lowest N and K uptake by maize grains and/or stover. This is mainly explained by the effect of nitrogen sources on grain and stover yields, since nutrient uptake calculated as multiplying yield dry weight by nutrient concentration (see Table 1 and 2 in Appendix). These results are in line with those obtained by Ismail *et al.* (2014).

TABLE 6. Means of N, P and K uptake by maize grains as affected by irrigation and nitrogen sources and levels

Treatments	N (kg ha <sup>-1</sup> )		P (kg ha <sup>-1</sup> )		K (kg ha <sup>-1</sup> )	
	2016	2017	2016	2017	2016	2017
<b>Irrigation</b>						
I1 (1.3 APE)	117.72 a	118.66 a	24.43 a	24.56 a	68.25 a	70.68 a
I2 (1.0 APE)	112.22 b	114.11 b	22.27 b	22.46 b	63.96 b	66.31 b
I3 (0.7 APE)	71.18 c	71.72 c	14.19 c	14.51 c	36.51 c	37.95 c
<b>N sources</b>						
Urea	96.83 c	98.52 c	20.94	20.83	52.64 c	55.11 c
A. N.	100.30 b	99.99 b	20.61	20.55	56.45 b	58.33 b
A. G.	104.06 a	105.98 a	20.17	19.93	59.62 a	61.42 a
<b>N levels</b>						
214 kg/ha	85.01 b	92.90 b	18.81 b	20.42 b	46.57 b	49.12 b
286 kg/ha	109.62 a	110.12 a	21.70 a	21.71 a	65.97 a	67.48 a

TABLE 7. Means of N, P and K uptake by maize stover as affected by irrigation and nitrogen sources and levels

Treatments	N (kg ha <sup>-1</sup> )		P (kg ha <sup>-1</sup> )		K (kg ha <sup>-1</sup> )	
	2016	2017	2016	2017	2016	2017
<b>Irrigation</b>						
I1 (1.3 APE)	80.34 b	81.47 b	24.28 b	24.28 b	98.27 b	100.07 b
I2 (1.0 APE)	84.92 a	86.83 a	26.22 a	27.24 a	112.93 a	114.66 a
I3 (0.7 APE)	54.35 c	54.74 c	15.01 c	16.11 c	69.63 c	71.57 c
<b>N sources</b>						
Urea	69.52 c	71.46 b	21.53	22.11	90.78 c	92.58 c
A. N.	72.34 b	72.24 b	21.65	22.51	92.27 b	93.97 b
A. G.	77.75 a	79.34 a	22.38	23.00	97.67 a	99.76 a
<b>N levels</b>						
214 kg/ha	67.84 b	68.71 b	20.16 b	21.06 b	86.97 b	89.12 b
286 kg/ha	78.50 a	80.04 a	23.51 a	23.94 a	100.24 a	101.67 a

TABLE 8. Means of N, P and K uptake by maize plants as affected by irrigation and nitrogen sources and levels

Treatments	N (kg ha <sup>-1</sup> )		P (kg ha <sup>-1</sup> )		K (kg ha <sup>-1</sup> )	
	2016	2017	2016	2017	2016	2017
<b>Irrigation</b>						
I1 (1.3 APE)	198.06 a	200.13 a	48.71 a	48.78 a	166.52 b	170.86 b
I2 (1.0 APE)	197.16 a	200.94 a	48.53 a	49.70 a	176.88 a	180.98 a
I3 (0.7 APE)	126.29 b	127.34 b	30.23 b	31.54 b	106.48 c	110.30 c
<b>N sources</b>						
Urea	167.26 c	170.79 c	43.11	43.86	144.39 c	148.21 b
A. N.	171.59 b	173.23 b	43.18	43.92	149.64 b	148.18 b
A. G.	182.64 a	186.19 a	44.21	44.04	158.39 a	162.14 a
<b>N levels</b>						
214 kg/ha	159.28 b	161.96 b	39.29 b	40.70 b	133.88 b	138.53 b
286 kg/ha	188.39 a	190.40 a	46.34 a	45.95 a	166.52 a	169.81 a

Considering nitrogen levels, the data clearly show that, regardless nitrogen sources, N, P and K uptake in grains and/or stover were markedly affected by nitrogen levels. Addition of 286 kg N ha<sup>-1</sup> yielded total N, P and K surpassed that due to 214 kg N ha<sup>-1</sup> by about 19.0, 17.7 and 33.3% in the first season. Similar trends were obtained in the second season as well as N, P and K uptake by grains or stover in both seasons. The increment of N, P and K uptake resulted in increasing nitrogen levels may be due to the effect of nitrogen levels on grains or stover as mentioned before. Also, this increase might be attributed to the increase in root surface per soil unit volume due to nitrogen application and accordingly increased the rate of nutrients absorption (Hassanien, 2009). These results are in harmony with those obtained by Ismail *et al.* (1999) and Gebrael *et al.* (2005).

#### Crop-water relations

##### Seasonal applied irrigation water (IW)

Data in table 9 show the amount of seasonal

applied water. The data revealed that, regardless the adapted nitrogen sources and levels, watering at 1.3 of APE (I<sub>1</sub>) resulted in higher amount of applied irrigation water found to be 8000 and 7750 m<sup>3</sup> ha<sup>-1</sup> in both seasons, respectively. On the other hand, watering at 1.0 (I<sub>2</sub>) and 0.7 (I<sub>3</sub>) of APE found to be 7010 and 6110 in the first season, and 6820 and 5920 m<sup>3</sup> ha<sup>-1</sup> in the second one, respectively. The applied water (IW) at 0.7, 1.0 and 1.3 of A.P.E. were distributed through 5, 6 and 7 irrigation events including sowing and first irrigation in both seasons. The reduction in seasonal applied water due to decrease in the A.P.E. is mainly attributed to the decrease of irrigation events. It is worthy to notice that, seasonal applied irrigation water did not respond to both nitrogen sources or levels. These results agree with those results obtained by El-Bably (2007), Eid *et al.* (2010) and Zorkany (2014).

**TABLE 9. Means of seasonal applied water, seasonal consumptive use, water utilization efficiency and water use efficiency as affected by irrigation treatments and nitrogen sources and levels**

Treatments	Seasonal applied water (m <sup>3</sup> ha <sup>-1</sup> )		Seasonal consumptive use (m <sup>3</sup> ha <sup>-1</sup> )		Water utilization efficiency (kg m <sup>-3</sup> )		Water use efficiency (kg m <sup>-3</sup> )	
	2016	2017	2016	2017	2016	2017	2016	2017
<b>Irrigation</b>								
I1 (1.3 APE)	8000 a	7750 a	6927 a	7084 b	0.88 b	0.92 b	1.02 b	1.01 b
I2 (1.0 APE)	7010 b	6820 b	6937 a	7150 a	0.98 a	1.02 a	0.99 c	0.95 c
I3 (0.7 APE)	6110 c	5920 c	4886 b	4585 c	0.78 c	0.82 c	1.08 a	1.05 a
<b>N sources</b>								
Urea	7040	6830	5823 c	6038 c	0.86 c	0.90 c	1.05 a	1.03 a
A. N.	7040	6830	6077 b	6235 b	0.88 b	0.92 b	1.03 b	1.01 b
A. G.	7040	6830	6349 a	6546 a	0.90 a	0.94 a	1.01 c	0.99 c
<b>N levels</b>								
214 kg/ha	7040	6830	5564 b	5758 b	0.81 b	0.85 b	1.04 a	1.02 a
286 kg/ha	7040	6830	6602 a	6787 a	0.94 a	0.99 a	1.01 b	0.99 b

*Seasonal consumptive use (CU)*

Mean values of seasonal consumptive use as affected by irrigation and nitrogen treatments for maize are presented in Table 9. Plants irrigated through 1.3 of A.P.E (I<sub>1</sub>) was accompanied with the highest seasonal consumptive use with an amount of 6927 and 7084 m<sup>3</sup> ha<sup>-1</sup> in both seasons, respectively, followed by I<sub>2</sub> with 6937 and 7150 m<sup>3</sup> ha<sup>-1</sup> in both seasons, respectively. Whereas, I<sub>3</sub> treatment exhibited the lowest seasonal consumptive use (4886 and 4585 m<sup>3</sup> ha<sup>-1</sup> in the two studied seasons, respectively). These results indicated that water consumptive use increased as soil moisture was maintained high by frequent irrigation. Also, it could be explained by higher frequent of irrigations provide chance for more consumption of water ultimately resulted in increasing transpiration and evaporation from the soil surface (Eid et al, 2010). Similar results were obtained by El-Tantawy *et al.* (2007).

*Water utilization efficiency (WUE, kg m<sup>-3</sup>)*

Water utilization efficiency or productivity of maize grains (kg m<sup>-3</sup>) obtained from each cubic meter of water consumed as affected by irrigation scheduling, nitrogen sources and nitrogen levels is presented in Table 9. Results indicate that the highest values of WUE were obtained under the irrigation at 1.0 of A.P.E (I<sub>2</sub>), followed by irrigation at 1.3 of A.P.E (I<sub>1</sub>). Whereas the irrigation at 0.7 of A.P.E (I<sub>3</sub>) exhibited the lowest WUE. These results could be attributed to the higher grain yield under I<sub>2</sub> treatment comparable to I<sub>1</sub> and I<sub>3</sub> treatments. Similar results were obtained by Hegab *et al.* (2014) and Ewis *et al.* (2015).

As for nitrogen sources, the results showed that water utilization efficiency was significantly affected by nitrogen sources. The effect of the studied nitrogen sources on WUE could be arranged in the descending order as follow: ammonia gas > ammonium nitrate > urea fertilizer. These results could be explained by the effect of these fertilizers on maize grain yield, since seasonal applied water was constant for each fertilizer sources.

Considering nitrogen levels, the data clearly showed that increasing nitrogen level from 214 to 286 kg ha<sup>-1</sup> had a positive effect on water utilization efficiency in both seasons, which mainly due to the increment of grain yield with increasing nitrogen level. The relative increasing of water utilization efficiency due to 286 kg N ha<sup>-1</sup> reached to 16.0 and 16.5% over 214 kg N ha<sup>-1</sup> in both seasons, respectively. These results agree with those obtained by Eid *et al.* (2010) and Ewis *et al.* (2016).

*Water use efficiency (WUE, kg m<sup>-3</sup>)*

Water use efficiency (WUE) is a parameter which indicates the capability of plants to utilize the soil moisture stored in the effective root zone. The water use efficiency as affected by irrigation scheduling and nitrogen sources and levels are shown in Table (9). The results revealed that irrigation at 0.7 of A.P.E. (I<sub>3</sub>) gave the highest values of WUE (1.08 and 1.05 kg grains m<sup>-3</sup> in both seasons, respectively), followed by irrigation at 1.3 of A.P.E. (1.02 and 1.01 kg maize grains m<sup>-3</sup> in the two seasons. On the other hand, irrigation

at 1.0 of A.P.E. produced the lowest water use efficiency (0.94 and 0.95 kg grains m<sup>-3</sup> in both seasons, respectively). The superiority of the effect of I<sub>3</sub> treatment is mainly due to the reduction in seasonal applied water. However, the reduction in WUE under I<sub>2</sub> treatment is attributed to the higher water availability which can reduce the amount and efficiency of water (Maman *et al.* 2003). In this regard Ehdaie *et al.* (1991) and Ebdon *et al.* (1998) who mentioned that the amount of water used and water use efficiency vary with climatic, soil conditions and the ability of the crops to extract water stored in soil. These results are in line with those obtained by Zorkany (2014).

As for nitrogen sources, the data indicated that water use efficiency was significantly responded to nitrogen sources. The effect of nitrogen sources on water use efficiency could be arranged in the descending order as follow: urea > ammonium nitrate > ammonia gas. These results may be due to the effect of different nitrogen fertilizers on seasonal consumptive use (Ewis *et al.*, 2016). Regarding nitrogen level, the data revealed that

increasing nitrogen level from 214 to 286 kg ha<sup>-1</sup> positively decreased water use efficiency. These results are mainly explained by the effect of nitrogen on improving the growth of roots and shoots of maize, consequently improved water absorption (Ewis *et al.*, 2016). These results coincided with those obtained by Yang *et al.* (2005), El-Atawy (2007) and Eid *et al.* (2010).

### Conclusion

The results of this investigation showed that the highest grain and stover yields of maize plants were obtained when plants were irrigated using 1.0 or 1.3 pan evaporation coefficient with no significant differences between them. However, the highest water productivity was obtained under irrigation with 1.0 pan evaporation coefficient which means that the possibility to save about 960 m<sup>3</sup> ha<sup>-1</sup> from the applied irrigation water with slightly insignificant reduction in maize yields. Therefore, it is recommended to apply irrigation water using 1.0 of A.P.E. and fertilized maize plants with anhydrous ammonia at the rate of 286 kg N ha<sup>-1</sup> to maximize maize production and save irrigation water.

### Appendix

TABLE 1. Means of N, P and K concentration in maize grains plants as affected by irrigation and nitrogen sources and levels

Treatments	N%		P%		K%	
	2016	2017	2016	2017	2016	2017
<b>Irrigation</b>						
I1 (1.3 APE)	1.65 a	1.66 a	0.33 a	0.34 a	0.98 a	0.97 a
I2 (1.0 APE)	1.64 a	1.65 a	0.33 a	0.33 a	0.88 a	0.89 a
I3 (0.7 APE)	1.48 b	1.48 b	0.28 b	0.28 b	0.75 b	0.76 a
<b>N sources</b>						
Urea	1.58 b	1.59 b	0.31	0.32	0.84 b	0.86 b
A. N.	1.59 b	1.58 b	0.32	0.32	0.84 b	0.86 b
A. G.	1.61 a	1.62 a	0.32	0.32	0.90 a	0.91 a
<b>N levels</b>						
214 kg/ha	1.56 b	1.56 b	0.31	0.31	0.77 b	0.79 b
286 kg/ha	1.62 a	1.62 a	0.31	0.31	0.94 a	0.96 a

TABLE 2. Means of N, P and K concentration in maize stover plants as affected by irrigation and nitrogen sources and levels

Treatments	N%		P%		K%	
	2016	2017	2016	2017	2016	2017
<b>Irrigation</b>						
I1 (1.3 APE)	1.08 a	1.09 a	0.33 a	0.34 a	1.44 a	1.45 a
I2 (1.0 APE)	1.01 a	1.00 a	0.30 b	0.30 b	1.24 b	1.25 b
I3 (0.7 APE)	0.87 a	0.88 a	0.24 c	0.25 c	1.15 b	1.15 b
<b>N sources</b>						
Urea	0.96 b	0.96 b	0.29	0.30	1.26 b	1.28 b
A. N.	0.96 b	0.98 b	0.29	0.30	1.26 b	1.27 b
A. G.	1.03 a	1.04 a	0.29	0.29	1.35 a	1.31 a
<b>N levels</b>						
214 kg/ha	0.93 b	0.93 b	0.27	0.28	1.22 b	1.23 b
286 kg/ha	1.04 a	1.05 a	0.30	0.30	1.33 a	1.33 a

## References

- Abd El-Hafeez, A. M., Awadalla, H. A. and Ismail, S. A. (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-Kader, M. G. (2002) Response of growth and yield of wheat (cv sids 7) to Fe and Zn application under ammonia injection. *Ph. D. Thesis*, Fac. of Agric. Moshtohor, Zagazig Univ. Egypt.
- Ali, M. E., Ismail, S. A., El-Hameid, A. H., El-Hussieny, O. H. M. and El-Sheref, G. F. H. (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. and Yin, X. (2003) Effects of Nitrogen Rate, Irrigation Rate, and Plant Population on Corn Yield and Water Use Efficiency. *Agron. J.* **95**, 1475-1482.
- AOAC (1990) *Official Methods of Analysis*, 15<sup>th</sup> ed. Association of Official analytical chemists. Washington D.C.
- Ashraf, M., Saeed, M. M. and Asghar, M. N. (2002) Evaporation Pan: A Tool for Irrigation Scheduling. *J. of Drain. Wat. Mana.*, **6** (1), 45-51.
- Azizian, A. and Sepaskhah, A. R. (2014) Maize response to different water, salinity and nitrogen levels: agronomic behavior. *International J. of Plant Production* **8** (1), 107-129.
- Dubey, A., Rathi, G. S. and Sahu, R. (2013) Effect of nitrogen levels on green fodder yield of oat (*Avena sativa* L.) varieties. *Forage Research*; **39**, 39-41.
- Ebdon, J. S., Petrovic, A. M. and Dawson, T. E. (1998) Relationship between carbon isotope discrimination, water use efficiency and evapotranspiration in Kentucky bluegrass. *Crop Science* **38**, 157-162.
- Eck, H. V. (1984) Irrigated corn yield response to nitrogen and water. *Agron. J.* **76**, 421-428.
- Ehdaie, B., Hall, A. E., Farquhar, G. D., Nguyen, H. T. and Waines, J. G. (1991) Water use efficiency and carbon isotope discrimination in wheat. *Crop Science* **31**, 1282-1288.
- Eid, S. M., El-Atawy, Gh. Sh. and EL-Shreif, M. A. (2010) Yield and some water relation of maize crop as influenced by irrigation scheduling and nitrogen fertilization rates at Middle North Delta. *J. Soil Sci. and Agric. Engineering*, Mansoura Univ., Vol. **1** (8), 801 – 813.
- 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-Bably A. Z. (2007) Irrigation scheduling of some maize cultivars using class A pan evaporation in north delta Egypt. *Bull. Fac., Agric., Cairo Univ.*, **58** (3), 222-232.
- El-Masry, A. A., Gohar, N. and El-Akabawy, M. A. (2006) The influence of nitrogenous fertilizer sources and some soil amendments on hull-less barley under alkali soil conditions. *Egypt. J. of Appl. Sci.*, **21**(11).
- EL-Sharkawy Anal F., Khalil, F.A.F. and Abd Elmaksoud, H.H. (2006) Effect of incorporating wheat crop residues into the soil, N-eate and irrigation interval on maize yield and some yield water relations. *Minufiya J. Agric. Res.* Vol. **31**, No 6, 1361-1373.
- El-Tantawy, M.M., Ouda, S. A. and Khalil, F.A. (2007) Irrigation scheduling for maize crop grown under middle Egypt conditions. *Res. J. Agric. and Biol. Sci.*, **3**, 456-62.
- El-Zubair, R. M., Fadlalla, B., Hussien, A. H. M. and Abdelkreim, M. (2015) Effect of different nitrogen fertilization levels on yield of maize (*Zea mays* L.) as winter forage. *IJSTR* **4** (10), 197-201.
- Ewis, M. M., Abd El-Latif, K. M. and Badawi, M. I. (2015) Effect of irrigation interval and phosphorus fertilization rate on faba bean (*Vicia faba* L.) yield, yield components and some crop-water relationships. *J. Soil Sci. and Agric. Eng.*, Mansoura Univ., **6** (5), 705-718.
- Ewis, M. M., Abd El-Latif, K. M. and Badawi, M. I. (2016) Response of maize (*Zea mays* L.) to moisture stress under different nitrogen fertilization levels. *J. Soil Sci. and Agric. Eng.*, Mansoura Univ., **7**(11), 865-872.
- Faki, H. H. (1991) Water allocation and its effect on faba bean technology adoplion in Shendi area. Pag 72-75 in Nile Valley Regional program on Cool-Season Food Leggumes and Wheat. Annual Report 1990/91, Sudan. ICARDA/ NVRPOC-017.
- FAO (2003) Unlocking the Water Potential of Agriculture. FAO, Coreporate Document Repository. 260 pp.
- Fashina, A. S., Olatunji, K. A. and Alasiri, K. O. (2002) Effects of different plant population and poultry manure on yield of Ugu (*Telfairia occidentalis*) in *Egypt. J. Soil. Sci.* **59**, No. 1 (2019)

- Lagos State, Nigeria in Proceedings of the annual Conference of Horticultural Society of Nigeria (HORTON), pp. 123-127.
- Galbiatti, J. A., Borges, M.J., Bueno, L.F., Garcia, A. and Vieira, R.D. (2004) Effect of different irrigation periods in the development, yield and seedling quality in the maize (*Zea mays* L.) crop. *Engenharia Agricola*.
- Gebraiel, M. Y., Gohar, M. N., Salem, F. S. and Wahba, H. W. A. (2005) Vegetative growth and yield of maize (*Zea mays* L.) as affected by nitrogen, potassium and zinc fertilization. *Egypt. J. Appl. Sci.*, **20** (28), 739-755.
- 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.
- Hafiz, Y. A. M. and Ewis, M. M. (2015) Effect of irrigation regime and potassium fertilizer rates on growth, yield, oil composition and some water relations of fennel plant (*Foeniculum vulgare* Mill) under Middle Egypt conditions. *Bull. Fc. Agric., Cairo Univ.*, **66**, 142-155.
- Hassanien, A. M. M. (2009) Nitrogen fertilizer requirements for corn in newly reclaimed land. M. Sc. Thesis, Fac. of Agric., Minia Univ., Egypt.
- Hegab, A. S. A., Fayed, M. T. B., Hamada, M. M. A. and Abdrabbo, M. A. A. (2014) Productivity and irrigation requirements of faba bean in North Delta of Egypt in relation to planting dates. *Annals of Agricultural Sci.*, **59** (2), 185-193.
- Igbal, A., Ayoub, M., Zaman, H. and Ahmed, R. (2006) Impact of nutrient management and legumes association on agro qualitative traits of maize forage *Pak. J. Bot.* **38**, 1079-1084.
- Ismail, S. A., Abd El-Hafeez, A. M. and Galal, O. A. (2014) Response of soybean (*Glycine max* L.) to microbial inoculation under chemical fertilization: 1- nodulation, yield and its components. *Egypt. J. of Appl. Sci.*, **29** (12B), 1237-1258.
- Ismail, S. A., Osman, A. Z. and El-Hamed, A. M. (1996) Effect of ammonia gas injection in alluvial soil with different rates, plant population and their interaction on garlic plants (*Allium sativum* L.). *Egypt. J. Appl. Sci.*, **11** (1), 151-160.
- Ismail, S.A., Morsy, M.A., Omran, A.A. and Foad, M.M. (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.
- Ismail, S.A., Morsy, M.A., Awad, S.S. and Salem, F.S. (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.
- Israelsen, O. W. and Hansen, V. E. (1962) *Irrigation Principles and Practices*. 3<sup>rd</sup> ed., John Willy and Sons. Inc., New York.
- Jat, H., Kaushik, M. K., Nepalia, V. and Singh, D. (2017) Effect of irrigation schedule and nitrogen fertilization on growth, yield and quality of fodder oat (*Avena sativa* L.). *Journal of Pharmacognosy and Phytochemistry*, 2017; **6**(4), 2040-2042.
- Khalil, F. A. F. and Mohamed, S. G. (2006) Studies on the interrelation among irrigation and maize varieties on yield and water relations using some statistical procedures. *Ann. Agric. Sci. Moshtouhor*; **44** (1), 393-406.
- Klute, A. (1986) *Methods of Analysis*. 2<sup>nd</sup> ed. Part 1: *Physical and Mineralogical Methods*. American Society of Agronomy, Mudson, Wisconsin, USA.
- Kuchenbuch, R. O., Ingram, K. T. and Buczko, U. (2006) Effects of decreasing soil water content on seminal and lateral roots of young maize plants. *Journal of Plant nutrition and Soil Science*, **169**, 814-848.
- Maman, N., Lyon, D. J., Mason, S. C., Galusha, T. D. and Higgins, R. (2003) Pearl millet and grain sorghum yield response to water supply in Nebraska. *Agronomy J.* **95**, 1618-1624.
- Markovic, M., Josipovic, M., Sostaric, J., Jambrovic, A. and Brkic, A. (2017) Response of maize (*Zea mays* L.) grain yield and yield components to irrigation and nitrogen fertilization. *J. Central European Agric.*, **18** (1), 55-72.
- Martin, D.L., Watts, D.G., Mielke, L.N., Frank, K.D. and Eisenhauer, D.E. (1982) Evaluation of nitrogen and irrigation management for corn production using water high in nitrate. *Soil Sci. Soc. Am. J.* **46**, 1056-1062.
- Michael A. M. (1978) *Irrigation-Theory and practices*. Vikas Publishing House, New Delhi, India.

- Nilahyana, A., Islam, M. A., Mesbah, A. O. and Garcia, A. G. (2018) Effect of irrigation and nitrogen fertilization strategies on silage corn grown in semi-arid conditions. *J. of Agronomy*, **8**, 208, 1-14.
- Norwood, C. A. (2000) Water use and yield of limited-irrigated and dryland corn. *Soil Sci. Soc. Am. J.* **64**, 365–370. [Abstract/Free Full Text].
- Obi, C. O., Nnabude, P. C. and Onucha, E. (2005) Effects of kitchen waste compost and tillage on soil chemical properties and yield of Okra (*Abelmoschus esculentus*), *Soil Sci.*, **15**, 69-76.
- Page, A. L., Miller, R. H. and Keeny, D. R. (1982) *Methods of Soil Analysis*. 2<sup>nd</sup> ed. Part 2: Chemical and Microbiological Properties. American Society of Agronomy, Madisons, Wisconsin, USA.
- Rahim, A., Rahamtullah, A. M. R. and Waraich, E. A. (2010) Effect of phosphorus application and irrigation scheduling on wheat yield and phosphorus use efficiency. *Soil & Environ.* **29** (1), 15 - 22, 2010.
- Sadik, M.K., Ismail, S.A., El-Hussieny, O.H.M. and Hashem, R.F. (2009) Influence of levels and methods of some organic and inorganic fertilizers application on maize: 1- Growth and nutrients uptake. *J. Agric. Sci.*, Mansoura Univ., **34** (7), 9001-9014.
- Sajedi, N. A., Ardakani, M. R., Naderi, A., Madani, H., Mashhadi, A. and Boojari, M. (2009) Response of maize to nutrients foliar application under water deficit stress conditions. *Am. J. Agric. Biol. Sci.*, **4**(3), 242-248.
- Sangakkara, U. R., Amarasekera, P. and Stamp, P. (2010) Irrigation regimes affect early root development, shoot growth and yields of maize (*Zea mays* L.) in tropical minor seasons. *Plant Soil and Environment* **56**, 2010 (5), 228–234.
- Shinde, S.A., Patange, M. J. and Dhage, S. J. (2014) Influence of irrigation schedules and integrated nutrient management on growth, yield and quality of rabi maize (*Zea mays* L.). *Int. J. Curr. Microbiol. App. Sci.* (2014) **3**(12), 828-832.
- Shirazi, S. M., Sholichin, M., Jamee, M., Akib, Sh. and Aziz, M. (2011) Effects of different irrigation regimes and nitrogenous fertilizer on yield and growth parameters of maize. *International Journal of Physical Sciences* Vol. **6** (4), pp. 677-683, 18 February, 2011.
- Snedecor, G. W. and Cochran, W. G. (1980) “*Statistical Methods*” 7<sup>th</sup> ed. Iowa State Univ., Press, Iowa, USA.
- Sommer, K. (2005) CULTAN – fertilization. Verlag Th. Mann, Gelsenkirchen, **218**. (In German).
- Stefano, P., Dris, R. and Rapparini, F. (2004) Influence of growing conditions and yield and quality of cherry. II. *Fruit. J. Agric. And Env.*, **2**, 307-309.
- Tayel, M.Y., El Gindy, A.M., Abd- El- Hady, M. and Ghany, H.A. (2007) Effect of irrigation systems on: yield, water and fertilizer use efficiency of grape. *Applied Sciences Research*, **3** (5), 367-372.
- Vites, F. G. (1965) Increasing water use efficiency by soil management in plant environment and efficient water use. *J. Amer. Soc. Agron.*, **26**, 537-546.
- Wang, X. and Xing, Y. (2017) Effects of irrigation and nitrogen on maize growth and yield components. © Springer International Publishing AG 2017: 63-74.
- Yang, T., Liang, Z. S., Xue, J. and Kang, S. (2005) Diversity of water use efficiency in various maize varieties. *Transaction of the Chinese Society of Agricultural Engineering*. **21** (10), 21-25.
- Zorkany, E. S. K. (2014) Scheduling irrigation of corn (*Zea mays*) using the evaporation pan methods under different potassium levels. *Ph. D. Thesis, Fac. of Agric. Minia Univ. Egypt*.

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## جدوله الري ومصادر ومستويات مختلفة للنيتروجين لانتاجية محصول الذرة الشامية وبعض العلاقات المائية

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أجريت هذه الدراسة بمزرعة محطة البحوث الزراعية بسدس- محافظة بني سويف - مصر خلال موسمي النمو ٢٠١٦، ٢٠١٧ لدراسة تأثير جدولة الري باستخدام وعاء البخر القياسي تحت مصادر ومستويات مختلفة من النيتروجين على انتاجية محصول الذرة وبعض العلاقات المائية. استخدم تصميم القطع المنشقة مرتان في أربع مكررات، وقد خصصت القطع الرئيسية لمعاملات جدولة الري وهي الري عند ٠،٧ - ١،٠ - ١،٣ من البخر التراكمي لوعاء البخر القياسي، في حين وزعت مصادر النيتروجين (الحقن بالأمونيا الغازية، وسماد نترات الأمونيوم، سمد اليوريا) على القطع المنشقة، كما أضيفت معدلات التسميد النيتروجيني (٢١٤، ٢٨٦ كجم نيتروجين/هكتار) في القطع المنشقة المنشقة. وعند الحصاد قدرت مكونات المحصول (عدد الصفوف في الكوز، عدد الحبوب في الصف، وزن المائة حبة) ومحصول الحبوب والقش. كما قدر امتصاص النيتروجين والفوسفور والبوتاسيوم في الحبوب والقش وكذلك بعض العلاقات المائية (كمية المياه الكلية المضافة، الاستهلاك المائي، كفاءة الاستفادة من مياة الري، كفاءة استخدام مياة الري). وقد أوضحت النتائج ما يلي:-

- أدى الري عند ١،٠ أو ١،٣ من البخر التراكمي لوعاء البخر القياسي الى زيادة معنوية في مكونات المحصول ومحصول الحبوب والقش وامتصاص عناصر النيتروجين والفوسفور والبوتاسيوم والكمية الكلية للمياه المضافة والاستهلاك ، ما عدا عدد الحبوب في الصف الذي لم يتأثر بجدولة الري. وكان الفرق تأثير الري عند ١،٣ و ١،٠ من البخر التراكمي لوعاء للبخر القياسي على محصول الحبوب والقش غير معنوي.

- أدى الري عند ١،٠ من البخر التراكمي لوعاء البخر القياسي الى أعلى قيم لكفاءة الاستهلاك واستخدام مياة الري، بينما أدى الري عند ٠،٧ من البخر التراكمي لوعاء البخر القياسي الى أقل القيم.

- أدى تسميد الذرة الشامية بالأمونيا الغازية الى أعلى قيم للمحصول ومكوناته وامتصاص العناصر والاستهلاك الموسمي لمياة الري وكفاءة الاستفادة واستخدام مياة الري، يليها التسميد بسماد نترات الأمونيوم، بينما أدى التسميد باليوريا الى اقل القيم، ما عدا عدد الحبوب في الصف التي لم تتأثر.

- أدى زيادة التسميد النيتروجيني الى ٢٨٦ كجم نيتروجين/هكتار الى تحسن كل صفات المحصول ومكوناته وامتصاص العناصر والعلاقات المائية ما عدا كمية المياه الكلية المضافة التي لم تتأثر بمستويات التسميد النيتروجيني.

- من نتائج الدراسة يمكن التوصية بري الذرة الشامية عند معامل البخر ١،٠ والتسميد النيتروجيني بمعدل ٢٨٦ كجم/هكتار على صورة حقن بالأمونيا للحصول على أعلى انتاجية لمحصول الذرة مع توفير حوالي ٩٦٠ م<sup>٣</sup> لكل هكتار مع عدم حدوث انخفاض معنوي في المحصول.