RESPONSE OF WHEAT PRODUCTIVITY TO IRRIGATION REGIMES AND NITROGEN FERTILIZATION LEVELS

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ABSTRACT

Wheat is the main cereal crop in Egypt. The gap between production and consumption is about 60%. Research efforts are needed to reduce this gap, therefore; the objective of this work was to study the effect of three water regimes as irrigation at 45%, 60% and 70% depletion of the available soil moisture, and three nitrogen fertilization levels on two wheat varieties (Giza 168 and Giza 171).The field experiments were carried out at Bahry El-Methaq region, Alexandria Governorate, Egypt during the two successive winter seasons of 2015/2016 and 2016/2017. The experimental design of the study followed split split plot design (SSPD) with three replicates, keeping two bread wheat cultivars {Giza 168 and Giza 171 } as the main plots, irrigation regimes (irrigation at 45%, 60% and 70% depletion of the available soil moisture) as subplot, and the three fertilization levels as 100%, 80% and 60% from recommended fertilizer rates of nitrogen fertilization common applied as sub-subplot. The results showed that seasonal ET_0 was 665.9 mm for the first season and 624.8 for the second season. Wheat crop transpiration was 600.28 mm at 2015-2016 growing season and 572.95 mm for the next season. The seasonal applied irrigation water in total was 2702.2 m^3, 2792.6 m^3 and 2879.1 m^3 at 45%, 60% and 70% depletion treatments for 2015-2016 growing season, respectively. The corresponding values for the next growing season were changed to 2802.5 m^3, 2687.4 m^3 and 2716.4 m^3. Based on the irrigation regimes and water balance by the budget technique, the irrigation events of wheat at 45%, 60% and 70% depletion treatments were 29, 23 and 21, which required irrigating for 23.17, 23.94 and 24.69 hours in the first season, respectively.

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The second season results changed to 28, 23 and 20 irrigations, which required irrigating for 24.4, 22.96 and 23.29 hours. The results indicated that the maximum grain yield and water use efficiency of wheat regardless of the variety under investigation could be obtained with irrigation at 60% depletion of the available soil moisture and 100% of the recommended nitrogen fertilization. The yield and water use efficiency of Giza 168 under these conditions were 2.78 ton/fed and 1.02 kg/m^3. While for Giza 171, 3.4 ton/fed and 1.24 kg/ m^3 were obtained with 22.3% and 21.6% increase in yield and water use efficiency, respectively. The results indicated a significant effect of crop cultivars and nitrogen fertilization levels on biological yield, straw yield, grain yield, WUE of grain yield and WUE of straw yield. Meanwhile, irrigation regimes showed insignificant effect on the previous parameters. The interaction of wheat cultivars, nitrogen fertilization levels and irrigation water regime levels showed insignificant effect on biological yield, straw yield, grain yield, WUE of grain yield and WUE of straw yield.

INTRODUCTION

Wheat is the most important cereal crop in the world in terms of area and production; it is a staple food for more than one third of the world population. In Egypt, wheat is the main winter cereal crop; it is used as a staple food grain for urban and rural societies and the straw is utilized as fodder for animals (Abdelmageed *et al.,* 2019). Wheat consumption has increased drastically due to overall population growth of about 2.0 % per year (World Bank, 2018). Egypt imports about 60 percent of wheat requirements (FAOSTAT, 2017), this reflects the size of the problem and the efforts needed to increase wheat production. Wheat represents almost 10 percent of the total value of agricultural production and about 20 percent of all agricultural imports. Since 2002, wheat has been managed to increase its share of the winter cropped area from around 41 percent to 47 percent. It is well suited to the Egyptian climate where it is grown as a winter crop, often followed by rice or maize in the summer.

Almost one-third of the total daily calorie intake per person in Egypt is from wheat. To bridge the gap between production and consumption of wheat or other crops in case of limited water resources, irrigation should be precisely managed by selecting a proper method of irrigation, and irrigation scheduling which based on crop requirements and soil properties (Kayam *et al.*, 2000). The irrigation schedule could be based on direct measurement of soil water status, water consumption based on meteorological data and monitoring of plant indicators (Odemiş and Bastug, 1999). According to Allen *et al.* (1998), the total growing season of winter wheat ranges from 180-250 days to mature. Mean daily temperature for optimum growth is between 15 and 20C°. The crop is moderately tolerant to soil salinity. For high yields its water requirements vary from 450 to 650 mm depending on climate and length of the growing season. The crop coefficient (Kc); relating maximum evapotranspiration ET_0 to crop evapotranspiration ETc, is 0.7 during the initial stage (20 days), from 0.7 to 1.15 during the development stage (50 days), 1.15 during the mid-season stage (60 days) and from 1.15 to 0.4 during the late-season stage (30 days), (Allen *et al.*, 1998). Noreldin *et al.* (2015) found that seasonal irrigation water applied for wheat (m^3ha^{-1}) under drip irrigation system were 3709, 2894 and 2079 m^3 ha^{-1} for 100, 75 and 50% ET, respectively, while for sprinkler irrigation system, 4143, 3405, 2666, 1927 and 1189 m^3ha^{-1} were applied for 100, 80, 60, 40 and 20% ET, respectively. Abdelraouf *et al.* (2014) evaluated the water use efficiency and economic viability of sprinkler irrigation system for wheat crop, the treatments included applying solid set sprinklers and hand move laterals. The irrigation intervals were once per week, twice per week and three times per week. The total irrigation water values varied from 3924 to 4081 m^3 ha^{-1} in 2009-2010 and 4314 to 4486 m^3 ha^{-1} at 2010-2011. The highest seasonal ET was obtained at 2010-2011 as 5417 m^3 ha^{-1}, the lowest value was observed at 2009-2010 as 4513 m^3 ha^{-1}. The lowest grain yield was 3333 kg ha^{-1}. Irrigation water use efficiency (IWUE) values varied from 1.0 to 1.43 kg m^{-3} in 2009-2010 and from 0.87 to 1.34 kg m^{-3} at 2010-2011. WUE values varied between 0.87 to 1.19 kg m^{-3} at 2009-2010 and from 0.79 to 1.16 kg m^{-3} at 2010-2011. Adeboye *et al.* (2015) stated that full irrigation should be practiced to maximize water productivity. Deficit

irrigation can be used to optimize water productivity. The amount of wheat yield reduction as a result of water stress is affected by the stage of grain development, where early grain development stage is more vulnerable to water stress than latter grain development stage (EL-Kholy *et al.,* 2005). Total cumulative evapotranspiration (ET) of wheat crops typically ranges from 200 to 500 mm, it can be less in non-irrigated semi-arid areas and reach to 600-800 mm under heavy irrigation.

The aim of the present investigation is to study the effect of three water regime of available water depletion (45%, 60% and 75%) and nitrogen fertigation levels on grain and straw yields, and water productivity of two wheat varieties (Giza 168 and Giza 171).

MATERIALS AND METHODS

The field experimental study was conducted on two wheat cultivars namely, Giza 168 and Giza 171. The experimental field was at Bahry El-Methaq region (altitude: 7m above sea level, latitude: 29° 0' 0" N, and longitude: 31° 7' 0" E), Bourg El-Arab, Alexandria Governorate, Egypt. The experiment was conducted during two successive winter seasons from 15 November to 23 April 2015/2016 and 12 November to 20 April 2016/2017. The experimental design was split split plot (SSPD) with three replicates, keeping wheat cultivars {Giza 168 (C_1), and Giza 171 (C_2)} as the main plots, irrigation regimes (irrigation at 45%, 60%, 70% depletion of the allowable soil moisture limit) as subplot. Three fertilization levels as 100%, 80% and 60% from recommended fertilizer rates of nitrogen fertilization common applied were as sub-subplot. The procedure, materials and methods applied during the study were as follows:

Water budget technique

The scheduling of irrigation by water budget was based on the water balance in soil within a specific limit of soil moisture content depending on soil and plant characteristics in addition to weather climatic data to estimate the crop consumptive use. The water budget technique in determining when to irrigate involves calculating the current water moisture content of the soil instead of measuring it, then comparing it to predetermined minimum

$$\theta_c = \theta_{FC} - (\theta_{FC} - \theta_{WP}) \times dr \qquad (1)$$

water content and irrigating to maintain soil water above the minimum level (critical). The critical water content was determined by the following equation:

where:

    θc soil critical moisture content (%),

   θ_{FC} soil moisture content at field capacity (%),

  θ_{WP} soil moisture content at the wilting point (%), and

   dr depletion ratio, which was taken as 0.45, 0.6 and 0.7.

The current water content of the soil was computed by the following equation:

$$\theta_i = \theta_{i-1} - \left(\frac{ET_c - ER}{10 \times Rd\ (1 - LR)}\right)_i \qquad (2)$$

where:

  θ_i, θ_{i-1} soil water content (%) at the end of the day i and day i–1, respectively

    ET_c daily crop evapotranspiration (mm/day)

    Rd effective root depth (m)

    LR ratio of leaching requirements

    ER effective rain (mm/day)

Leaching requirements (*LR*) of the soil were estimated according to Doorenbos and Pruitt (1977) by the following equation:

$$LR = \frac{EC_w}{5EC_e - EC_w} \qquad (3)$$

where:

  EC_e electrical conductivity of the saturation extract.

  EC_w electrical conductivity of the irrigation water,

Once the time to irrigate has been determined, the usual practice was to fill the root zone to the field capacity by applying required irrigation depth as follow:

$$IAW = \frac{10 \times Rd\left(\theta_{FC} - \theta_c\right)}{\eta} \qquad (4)$$

where:

    IAW   depth of irrigation water (mm),

    θ_c volumetric water content (%) directly prior to irrigation.

    η system irrigation efficiency (decimal).

The irrigation time was determined by following equation:

$$Ti = \frac{IAW}{I} \qquad (5)$$

where:

  Ti   irrigation time (hr/period)

  I   sprinkler application rate (mm/hr)

The application rate by sprinkler was determined by:

$$I = \frac{q \times 1000}{S \times L} \qquad (7)$$

where:

  q   sprinkler discharge (m^3/hr)

  S   distance between sprinklers (m)

  L   distance between laterals(m)

The daily wheat crop water requirement of wheat was estimated by:

$$ET_c = ET_o * Kc \qquad (8)$$

where:

    ET_o daily reference evapotranspiration (mm/day).

    Kc   daily crop coefficient.

Reference evapotranspiration (ET$_0$) was calculated by using the weather data of the local meteorological weather station for 2015-2016 and 2016-29017 seasons according to Penman-Monteith method (Allen *et al.*, 1998) as follows:

$$ETo = \frac{0.408\Delta(R_n - G) + \gamma \dfrac{900}{T + 273} u_2(e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)} \qquad (9)$$

where:

ETo potential evapotranspiration (mm/day),

R_n net radiation at the crop surface (MJ/m^2 day),

G soil head flux density (MJ/ m^2 day),

T mean daily air temperature (^{o}C) measured at 2 m height,

U_2 wind speed (m/s) at 2m height,

E_s saturation vapor pressure (kPa),

e_a actual vapor pressure (kPa),

e_s - e_a vapor pressure deficit (kPa),

Δ slope of the vapor pressure curve (kPa/ ^{o}C), and

Γ psychometric constant (kPa/ ^{o}C).

The daily value of crop coefficient of wheat (Kc) considered constant as 0.7 along the initial stage for 30 days, meanwhile 1.15 along 60 days along the midseason stage. In development and late season, the crop coefficient changes linearly along these two stages. The following equation was used to get the daily value as follow (Allen *et al.*, 1998):

$$Kc(i) = Kc_{prev.} + \left[\frac{i - \sum L_{prv.}}{L_{stage}} \right] \left(Kc_{next} - Kc_{prev} \right) \qquad (10)$$

where:

$Kc\ (i)$ crop coefficient of the day No. i

Kc_{prev} Kc value of the previous stage

L_{stage} length of the stage under consideration (days)

$\Sigma(L_{prev})$ sum of the lengths of the previous stages (days)

Kc_{next} Kc value of the next stage

Effective root depth (R_d)

The estimation of wheat effective root depth (Rd) was based on local observations of neighborhood fields for the same cultivars and cultivated at the same conditions. The maximum depth of roots was obtained after 100 day from planting. According to Duke *et al.* (1985) the root depth was assumed to increase linearly as a function of time from specified minimum root depth at "root development date" to a maximum root depth at the "effective cover date". Based on this assumption and the local

observations, the computation of the effective root depth was estimated during the crop growing seasons according to the formula:

$$Rd_i = Rd_{ini} + \frac{D_i - D_p}{D_{max} - D_p}(Rd_{max} - Rd_{ini}) \qquad D_i < D_{max} \qquad (11)$$

$$Rd_i = Rd_{max} \qquad\qquad\qquad\qquad\qquad D_i \geq D_{max} \qquad (12)$$

where:

Rd_i	effective root depth at day i.
Rd_{ini}	initial effective root depth at planting (assumes in the study as 10 cm).
Rd_{max}	maximum effective root depth (0.7 m).
D_i	current calendar (Julian) day of the year.
D_p	planting day
D_{max}	day of effective root cover (maximum effective root depth)

Crops:

The trading name and pedigree of wheat bread wheat cultivars are presented in Table (1). The study on the two-wheat cultivar was conducted during two successive winter seasons of 2015/2016 and 2016/2017. The sowing date was at 15 November and the harvest was at 23 April during the growing season of 2015/2016, the next growing season started at 12 November and continued till 20 April. The cultivation practices were conducted during the two successive seasons according to the recommended agricultural practices for the region.

Tab. (1): The treading name and pedigree of the wheat cultivars.

Symbol	Cultivars	Pedigree
C1	Giza 168	MRL/BUC//SERI CM93046-8M-0Y-0M-2Y-0B-0GZ
C2	Giza 171	SAKHA 93 / GEMMEIZA 9

Soil:

Soil samples were collected from four different randomized locations at two different soil depths in range of 0-30cm and 30-60cm. These samples were analyzed at Nubaria Research Station. Soil physical properties (Table, 2), were determined according to Black *et al.* (1982). The field was prepared thoroughly by plowing and harrowing then removing the

different types of plant debris then calcium super phosphate (15.5% P_2O_5) at the rate of 200 kg/fad and potassium sulfate (48.5% K_2O) at the rate of 50 kg/fad were broadcasted. Wheat grains were hand sewn at the rate of 60 kg/fad. After planting, all other cultural practices for wheat crop were carried out according to the recommended for the region. It also pulverized and leveled. Harvesting was after 160 days from sowing for the both seasons.

Irrigation Systems:

A fixed sprinkler irrigation system was used to conduct the field experiment study. The components and specifications of the system are summarized in Table (3). The sprinkler jet discharge was volumetrically measured by placing two flexible hoses over the sprinkler nozzles and receiving the flowing water in calibrated containers (20 liters). The time to fill the container was recorded by digital stopwatch, and the discharge was calculated as m^3/h. The sprinkler base pressure was measured using a hypodermic needle assembly and dial pressure gage as indicated by the ASAE (1988) standard.

Tab. (2): Soil physical properties for experimental site.

Soil depth (cm)	0-30	30-60	Average
Sand	73.5	73.0	73.25
Silt	15.5	14.6	15.05
Clay	11.0	12.4	11.7
Soil texture	Sandy loam	Sandy loam	Sandy loam
Bulk density (g.cm^{-3})	1.57	1.51	1.54
θ_s (m^3.m^{-3})	0.44	0.43	0.435
F.C. (m^3.m^{-3})	0.215	0.195	0.205
P.W.P (m^3.m^{-3})	0.12	0.115	0.1175
A.W. (m^3.m^{-3})	0.095	0.08	0.0875
k_s (mm.hr^{-1})	44.5	46.1	45.3

Tab. (3): Components and specifications of the sprinkler irrigation system at the experimental site.

Component	Specification
Sprinkler type	Aqua (Indian)
Nozzle size (mm)	ø 10.30×5.60
Raiser height (cm)	120
Steel riser diameter (mm)	33.4
Operating pressure (kPa)	350
Ave. sprinkler discharge (m^3/h)	9
Sprinkler spacing (m)	18×18
No. of sprinklers per lateral	4
Wetting diameter (m)	46.4
PVC. lateral diameter(mm)	90
laterals operating together	2
PVC main line diam. (mm)	125
Pump discharge (m^3/h)	72
Pump pressure head (kPa)	540
Power of elect. motor (kW)	18.5
motor pump speed (rpm)	1450

Statistical design and tested treatments:

A split split plot design (SSPD) with three replicates was adopted in the current study as follow:

a) Two wheat cultivars {Giza 168 (C_1), and Giza 171 (C_2)} was allocated in the main plots.

b) Three irrigation regimes {irrigation at 45% ($AWD_{45\%}$), 60% ($AWD_{60\%}$) and 70% ($AWD_{70\%}$) depletion of the available soil moisture} in the subplot.

c) Three fertigation levels (100%, 80% and 60% from recommended fertilizer rates of nitrogen fertilization) in the sub-subplot.

Water productivity *WP*:

The water productivity (*WP; kg/m³*) was calculated according to Jensen (1983) as a ratio between the grain yield per fed (kg/fed) over the gross applied irrigation water per fed (m^3/fed).

Yield and yield components.

At harvest, the central six rows of each plot, with four meters long, were harvested and the data were recorded for grain yield and biological yield.

Data analysis:

The data were analyzed using Costat 6.311 win statistical program CoHort Software (2005). Average values from the three replicates of each treatment were interpreted using the analysis of variance (ANOVA). The Duncan's Multiple Range Test (SNK) was used for comparisons among different sources of variance.

RESULTS AND DISCUSSIONS

Sprinkler validity:

The application rate by the sprinkler (I) was 27.78 mm/hr. To ensure the suitability of the sprinkler application rate for avoiding surface water runoff, the application rate by the sprinkler was compared with the soil basic infiltration rate or the soil saturated hydraulic conductivity (45.3 mm/hr). The results indicated that the ratio is less than 2/3, which means that the sprinkler is totally safe for avoiding runoff losses and eliminating free water evaporation from the soil surface.

Potential evapotranspiration (ET_0):

Daily ET_0 (mm/day) along the two growing seasons of wheat was calculated by Penman-Monteith Eq. (9) and applying the weather data of mean temperature, mean relative humidity and wind speed during 2015/2016 and 2016/2017 seasons (Fig.,1; Fig., 2). Due to lack of the previous weather data from measurements of short wave radiation or the actual sun duration, an assumption of actual to maximum sun duration (n/N) was used as 0.77 and the equations of appendix I were used to determine the reference evapotranspiration by **Excel spreadsheets.** Results of daily ET_0 along the 2015-2016 and 2016-2017 growing seasons are presented in Fig. (1) and Fig. (2), respectively. Seasonal ET_0 was 665.9 mm for the first season and 624.8 for the second season. The average daily ET_0 were 4.16 and 3.91 for the same previous order.

Evapotranspiration of the wheat (ETc):

Daily ETc of the wheat was estimated by Eq. (8). The daily ETc of wheat along the two growing seasons are presented in Fig. (1) and Fig. (2). The

results showed that, ETc values were gradually decreased as the plant age progressed till the midseason stage, then the rate was increased till the end of the growing season.
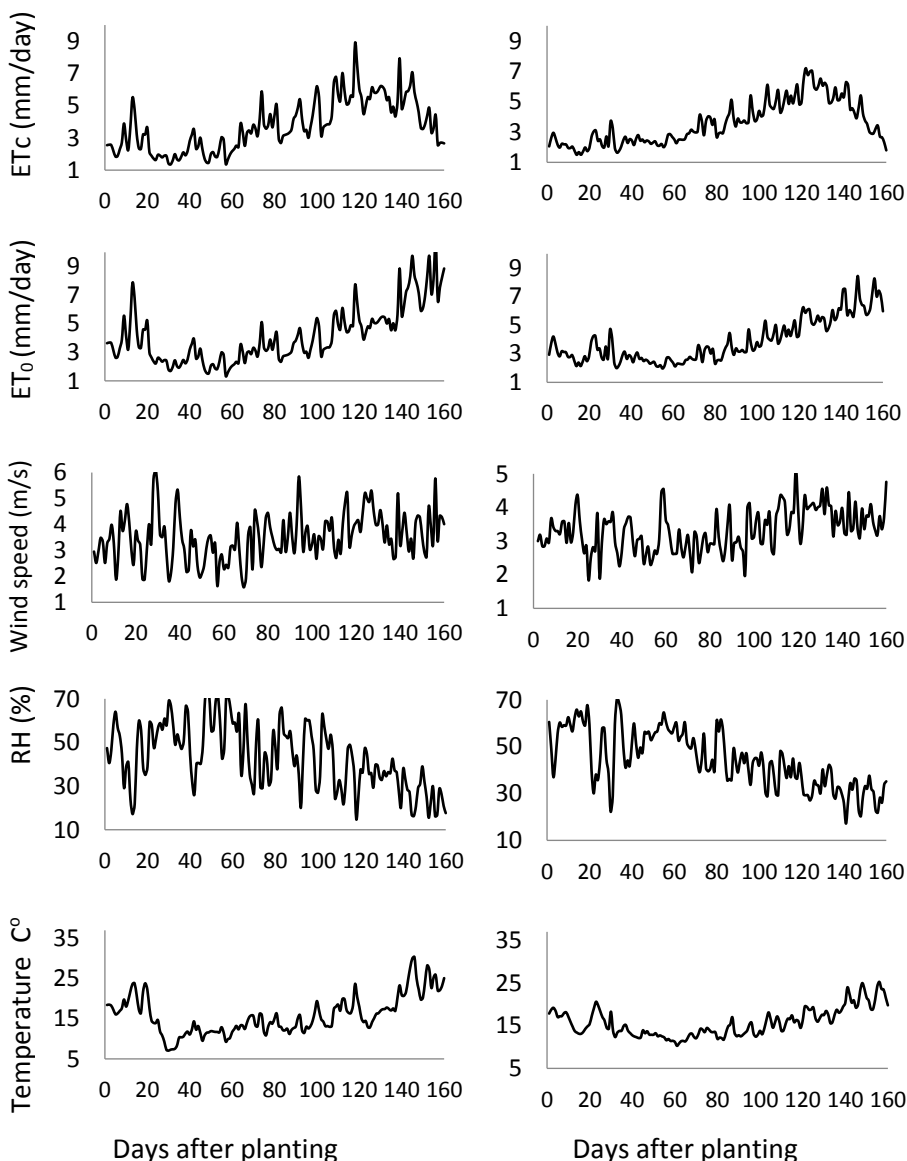

Fig. (1): Weather data, ET_0 and ETc along the 2015-2016 growing season of wheat.

Fig. (2): Weather data, ET_0 and ETc along the 2016-2017 growing season of wheat.

The reason of such trend is due to decreased temperature, relative humidity, wind speed and ET_0. The seasonal ETc was 600.28 mm for 2015-2016 growing season and 572.95 mm for the next season. Average value of ETc was 3.76 mm during 2016-2017 growing season and 3.55 mm at the second season.

Irrigation applied water (*IAW*):

The irrigation water was applied to wheat according to the proposed irrigation regimes and the water budget balance as $AWD_{45\%}$, $AWD_{60\%}$ and $AWD_{70\%}$ treatments. The seasonal irrigation applied water (including 30% as leaching requirements and the effective rain) were 643.4 mm (2702.2 m^3/fed), 646.9 mm (2792.6 m^3/fed) and 685.5 mm (2879.1 m^3/fed) for the 2015-2016 growing season at $AWD_{45\%}$, $AWD_{60\%}$ and $AWD_{70\%}$ treatments, respectively. The amounts changed to 667.3 mm (2802.5 m^3/fed), 637.7.9 mm (2687.4 m^3/fed) and 646.75 mm (2716.4 m^3/fed) at the next growing season. The dates of irrigation events, depth of water per irrigation, the sprinkler system operating time per irrigation as a result of the daily water budget analyses of 2015-2016 and 2016-2017 growing seasons are given in Tab. (4) and Tab. (5), respectively. The last 10 -14 days before harvesting, the irrigation was terminated to decrease the moisture contents of the grain to dry enough for suitable harvesting. The fluctuations of irrigation applied water along the growing seasons were referred to the changes in climatic conditions, plant water requirements and plant growth.

Soil moisture balance results by budget technique:

The logic of the water balance method in soil water analyses depends on replenishing the depleted water in the root zone once it reaches a specific critical soil moisture content that predefined by the user. In the current study, the criteria of irrigation depended on replenishing the soil moisture once it reaches 45% ($AWD_{45\%}$), 60% ($AWD_{60\%}$) and 70% ($AWD_{70\%}$) depletion of the soil available water. Under these circumstances, an irrigation event should be carried out once the soil moisture reaches to 16.4%, 15.38% and 14.35% in $AWD_{45\%}$, $AWD_{60\%}$ and $AWD_{70\%}$ treatments, respectively. The plant daily consumptive use, effective rain and leaching requirements were considered when the daily depletion was determined. The next step was to calculate the irrigation depth that returns

the soil moisture back to soil field capacity, considering the irrigation system efficiency.

Tab. (4): Depth of gross irrigation water and operating time of irrigation by water balance under different irrigation water regimes for 2015-2016 growing season.

RIGIEM No.1 (AWD$_{45\%}$)			RIGIEM No.2 (AWD$_{60\%}$)			RIGIEM No.3 (AWD$_{70\%}$)		
Date	Gross water/irri. mm	Operating time hr/irri	Date	Gross water/irri. mm	Operating time hr/irri	Date	Gross water/irri. mm	Operating time hr/irri
15/11	8.75	0.32	15/11	8.75	0.32	15/11	8.75	0.32
17/11	5.30	0.19	17/11	5.30	0.19	17/11	5.30	0.19
20/11	6.38	0.23	20/11	6.38	0.23	21/11	10.55	0.38
22/11	4.70	0.17	22/11	4.70	0.17	26/11	8.54	0.31
26/11	2.24	0.08	27/11	9.84	0.35	28/11	11.32	0.41
30/11	10.48	0.38	30/11	10.48	0.38	04/12	15.40	0.55
04/12	6.71	0.24	05/12	14.41	0.52	10/12	20.21	0.73
08/12	12.12	0.44	10/12	15.37	0.55	20/12	24.00	0.86
14/12	14.85	0.53	18/12	20.27	0.73	26/12	25.94	0.93
21/12	17.75	0.64	25/12	24.47	0.88	04/01	32.23	1.16
25/12	14.44	0.52	31/12	24.87	0.90	22/01	43.65	1.57
30/12	19.81	0.71	20/01	34.13	1.23	30/01	41.48	1.49
06/01	22.70	0.82	27/01	39.16	1.41	12/02	47.27	1.70
20/01	28.90	1.04	11/02	38.29	1.38	22/02	50.07	1.80
25/01	29.64	1.07	21/02	48.40	1.74	03/03	60.92	2.19
31/01	26.55	0.96	27/02	45.88	1.65	10/03	56.92	2.05
09/02	29.74	1.07	06/03	41.14	1.48	15/03	55.49	2.00
14/02	28.99	1.04	12/03	50.04	1.80	21/03	54.66	1.97
22/02	34.26	1.23	17/03	48.40	1.74	28/03	58.29	2.10
27/02	33.09	1.19	22/03	47.20	1.70	05/04	54.61	1.97
05/03	32.30	1.16	28/03	46.34	1.67			
09/03	32.90	1.18	04/04	43.97	1.58			
13/03	39.30	1.42	08/04	37.08	1.34			
17/03	33.04	1.19						
21/03	35.20	1.27						
25/03	37.03	1.33						
02/04	35.57	1.28						
07/04	40.61	1.46						
∑	643.37	23.17	∑	664.89	23.94	∑	685.60	24.69

Tab. (5): Depth of gross irrigation water and operating time of irrigation by water balance under different irrigation water regimes for 2016-2017 growing season.

RIGIEM No.1 (AWD$_{45\%}$)			RIGIEM No.2 (AWD$_{60\%}$)			RIGIEM No.3 (AWD$_{70\%}$)		
Date	Gross water/irri. mm	Operating time hr/irri	Date	Gross water/irri. mm	Operating time hr/irri	Date	Gross water/irri. mm	Operating time hr/irri
15/11	8.75	0.45	15/11	8.75	0.45	15/11	8.75	0.32
17/11	5.38	0.28	17/11	5.38	0.28	17/11	5.38	0.19
19/11	5.37	0.28	19/11	5.37	0.28	20/11	10.09	0.36
21/11	4.06	0.21	22/11	8.83	0.45	23/11	9.29	0.33
23/11	4.51	0.23	25/11	8.68	0.45	27/11	12.69	0.46
26/11	8.18	0.42	29/11	11.32	0.58	02/12	13.79	0.50
30/11	10.50	0.54	04/12	14.91	0.77	06/12	13.47	0.49
04/12	11.53	0.59	07/12	11.94	0.61	11/12	21.71	0.78
07/12	11.94	0.61	11/12	14.82	0.76	15/12	17.84	0.64
11/12	14.82	0.76	15/12	17.84	0.92	24/12	27.86	1.00
14/12	9.96	0.51	23/12	22.24	1.14	31/12	29.97	1.08
18/12	14.47	0.74	29/12	26.35	1.36	12/01	34.50	1.24
24/12	15.49	0.80	08/01	30.38	1.56	22/02	60.67	2.18
29/12	20.96	1.08	20/02	44.26	2.28	01/03	52.85	1.90
06/01	20.82	1.07	26/02	44.25	2.28	07/03	51.21	1.84
14/01	26.26	1.35	04/03	48.77	2.51	14/03	60.93	2.19
19/02	36.97	1.90	09/03	41.76	2.15	19/03	56.40	2.03
24/02	32.97	1.70	15/03	49.98	2.57	26/03	55.49	2.00
01/03	36.03	1.85	19/03	43.14	2.22	01/04	51.05	1.84
06/03	40.53	2.09	25/03	42.62	2.19	11/04	52.81	1.90
11/03	38.84	2.00	30/03	43.42	2.23			
15/03	32.73	1.68	08/04	47.56	2.45			
18/03	28.75	1.48	14/04	45.14	2.32			
23/03	36.68	1.89						
27/03	37.66	1.94						
01/04	40.93	2.11						
09/04	35.23	1.81						
14/04	37.09	1.91						
∑	667.25	24.03	∑	637.72	22.96	∑	646.75	23.29

Sometimes after heavy rains, the soil moisture exceeded the field capacity to the saturation zone. In this case, the soil moisture was considered at the field capacity by the end of the day as recommended by Allen *et al.* (1998). This is true because the gravitational water moves to deep percolation rapidly especially in sandy soil and the plant root does not absorb water over the field capacity limits. Results of daily moisture content of the suggested water regime during the growing seasons of 2015-2016 and 2016-2017 are presented in Fig. (3) and Fig (4), respectively. The validity of the method was studied by Berry *et al.* (2004) and proved that the method is fair enough to predict the soil moisture content by soil water balance.

Wheat productivity and water use efficiency:

By the end of each growing season, biological yield straw yield and grain yield were determined under the three irrigation regimes and the three nitrogen fertilization levels for Giza 168 and Giza 171 varieties during the 2015-2016 and 2016-2017 growing seasons (Table, 6). The two seasons average of irrigation applied water and yield components of wheat are given in Table (7). The results indicated that the maximum yield, yield components and water use efficiency regardless of the wheat variety were obtained with the irrigation at $AWD_{60\%}$ and nitrogen fertilization at 100% of recommended. The average biological yield, straw yield and grain yield of Giza 168 were 9.82 ton/fed, 6.5 ton/fed and 2.78 ton/fed, respectively. While, the same parameters of wheat Giza 171 were 11.69 ton/fed, 8.28 ton/fed and 3.4 ton/fed. Results of WUE for biological yield (Twue), straw yield (Swue) and grain yield (Gwue) are presented in Fig. (5). For wheat Giza 168 maximum Twue, Swue and Gwue were 3.39 kg/m^3, 2.78 kg/m^3 and 1.02 kg/m^3 with $AWD_{60\%}$ irrigation regime and 100% nitrogen fertilization, respectively. These values increased to be 4.27 kg/m^3, 3.40 kg/m^3 and 1.25 kg/m^3 for wheat Giza 171. The results in Tab. (7) also indicated that the maximum yield parameters of wheat Giza 171 were higher than Giza 168 by 26.0%, 27.4% and 22.3% for biological, straw and grain yields, respectively.
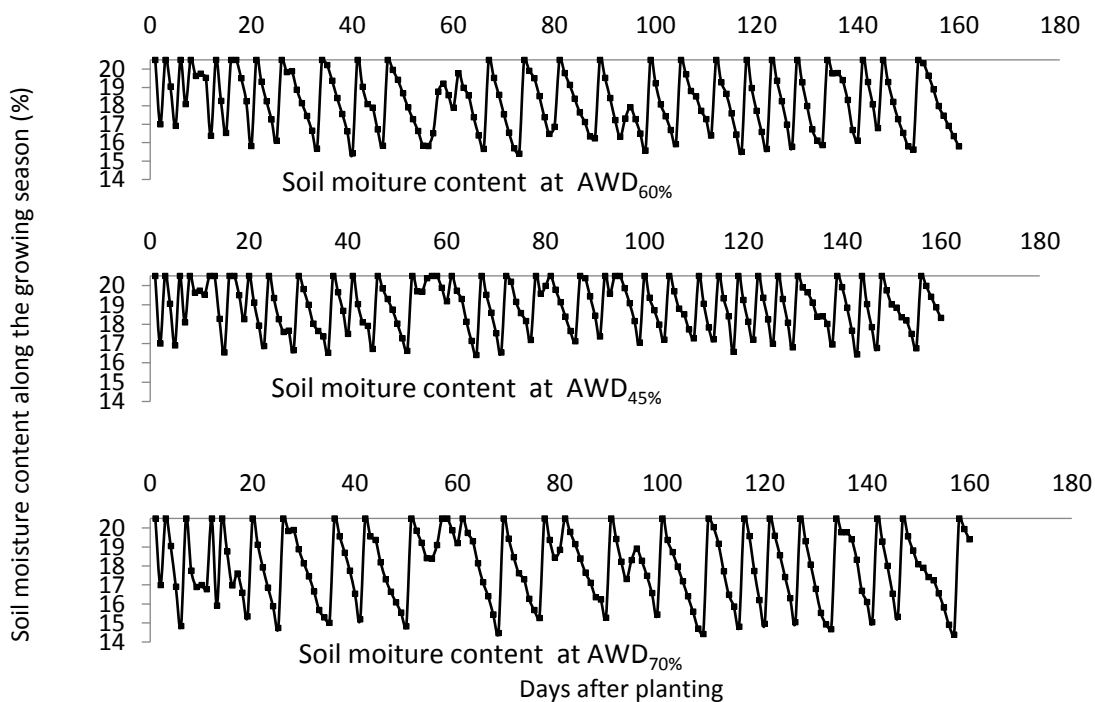
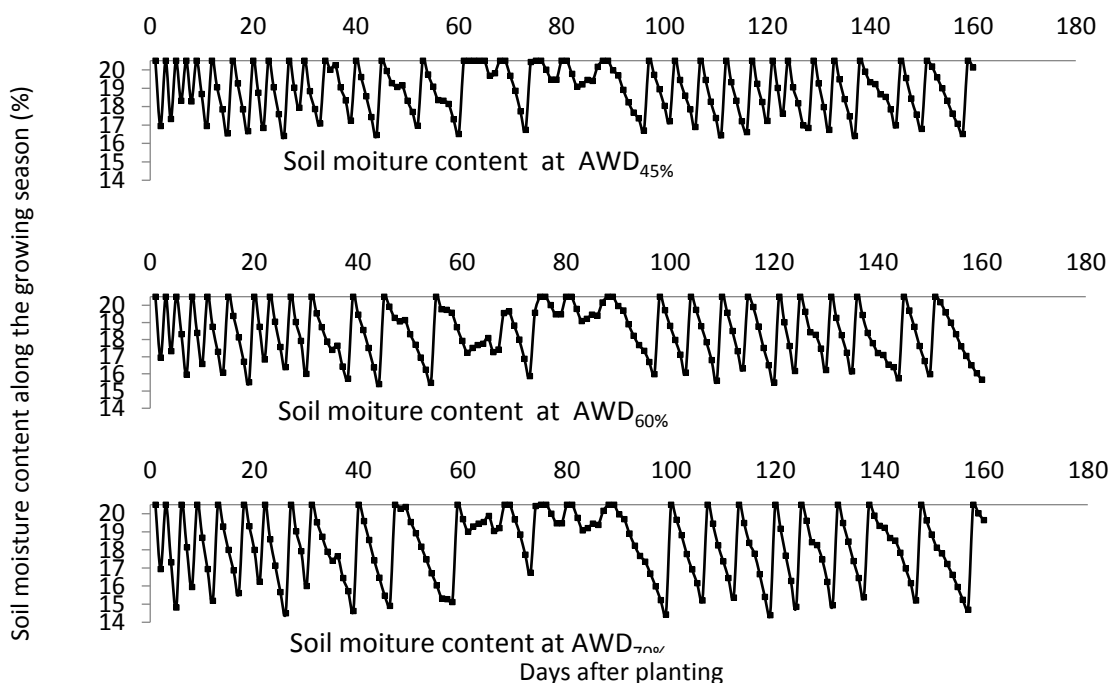Fig. (3): Soil moisture content along the 2015-2016 growing season of wheat.

Fig. (4): Soil moisture content along the 2016-2017 growing season of wheat.
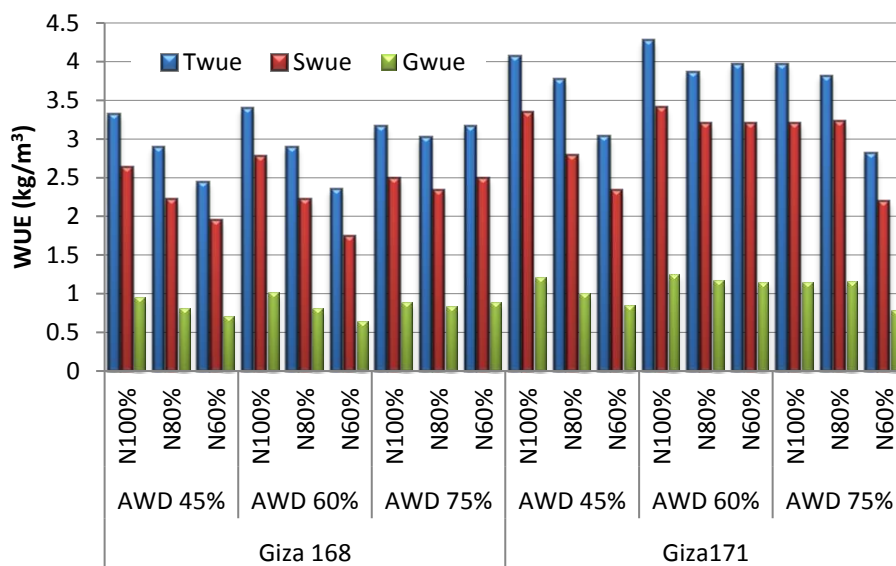
Fig. (5): WUE of biological, straw and grain yields versus fertilization and water regime.

The statistical analyses results:

The statistical analyses results showed that a significant effect due to crop cultivars and nitrogen fertilization levels on biological yield, straw yield, grain yield, water use efficiency of grain yield and water use efficiency of straw yield. Meanwhile irrigation water regime levels showed insignificant effect on the previous parameters. The interaction of wheat cultivars, nitrogen fertilization levels and irrigation water regime levels showed insignificant effect on biological yield, straw yield, grain yield, water use efficiency of grain yield and water use efficiency of straw yield. The interaction of wheat cultivars and irrigation water regime showed insignificant effect on biological yield, grain yield and WUE of grain and straw yields at the growing season of 2015-2016. The same behaviors observed at the next growing season expect significant effect noticed on both grain yield and WUE of the grain yield. The interaction of the nitrogen fertilization level and irrigation water regime indicated insignificant effect on biological yield, straw yield and WUE of the straw yield. The complete results of the statistical analyses are given in Tables 1, 2 Appendix II.

Tab. (6): Yield components of wheat Giza 168 and 171 as influenced by irrigation regime and nitrogen fertilization level.

Wheat variety	Water regime	N fertilizer	Biological yield ton/fed		Grain yield Ton/fed		Gross irrigation water m³/fed	
			2015-2016	2016-2017	2015-2016	2016-2017	2015-2016	2016-2017
Giza 168	AWD$_{45\%}$	N100%	9.29	8.95	2.67	2.60	2702.2	2802.5
		N80%	8.00	7.79	2.24	2.19	2702.2	2802.5
		N60%	6.70	6.73	1.94	1.95	2702.2	2802.5
	AWD$_{60\%}$	N100%	9.36	9.19	2.80	2.76	2792.5	2678.4
		N80%	8.54	8.47	2.30	2.17	2792.5	2678.4
		N60%	6.36	6.46	1.73	1.76	2792.5	2678.4
	AWD$_{70\%}$	N100%	8.86	8.84	2.50	2.49	2879.5	2716.4
		N80%	8.47	8.41	2.35	2.31	2879.5	2716.4
		N60%	6.57	6.37	1.96	1.89	2879.5	2716.4
Giza171	AWD$_{45\%}$	N100%	11.41	10.93	3.37	3.30	2702.2	2802.5
		N80%	10.32	10.39	2.77	2.79	2702.2	2802.5
		N60%	8.28	8.36	2.32	2.34	2702.2	2802.5
	AWD$_{60\%}$	N100%	11.75	11.62	3.43	3.39	2792.5	2678.4
		N80%	10.73	10.39	3.25	3.14	2792.5	2678.4
		N60%	8.20	7.79	2.31	2.17	2792.5	2678.4
	AWD$_{70\%}$	N100%	11.07	11.07	3.20	3.20	2879.5	2716.4
		N80%	10.66	10.66	3.23	3.23	2879.5	2716.4
		N60%	8.02	7.70	2.27	2.12	2879.5	2716.4

Tab. (7): Average of irrigation water and yield components of wheat Giza 168 and 171 versus irrigation regime and nitrogen fertilization.

Wheat variety	Water regime	N fertilizer	Average irrigation water m3/fed	Average yield ton/fed			Average Water use efficiency %		
				Total	Straw	Grain	Total	Straw	Grain
Giza 168	AWD$_{45\%}$	N100%	2752.30	9.12	6.49	2.63	3.32	2.36	0.96
		N80%	2752.30	7.89	5.68	2.21	2.89	2.08	0.81
		N60%	2752.30	6.72	4.77	1.95	2.44	1.73	0.71
	AWD$_{60\%}$	N100%	2735.48	9.28	6.50	2.78	3.39	2.38	1.02
		N80%	2735.48	7.89	5.68	2.21	2.89	2.08	0.81
		N60%	2735.48	6.41	4.66	1.74	2.34	1.71	0.64
	AWD$_{70\%}$	N100%	2797.94	8.85	6.35	2.49	3.16	2.27	0.89
		N80%	2797.94	8.44	6.11	2.33	3.02	2.18	0.83
		N60%	2797.94	8.85	6.35	2.49	3.16	2.27	0.89
Giza171	AWD$_{45\%}$	N100%	2752.30	11.17	7.84	3.34	4.06	2.85	1.21
		N80%	2752.30	10.35	7.57	2.78	3.76	2.75	1.01
		N60%	2752.30	8.32	5.99	2.33	3.02	2.18	0.85
	AWD$_{60\%}$	N100%	2735.48	11.69	8.28	3.40	4.27	3.03	1.25
		N80%	2735.48	10.56	7.36	3.19	3.86	2.69	1.17
		N60%	2735.48	11.07	7.87	3.20	3.96	2.81	1.15
	AWD$_{70\%}$	N100%	2797.94	11.07	7.87	3.20	3.96	2.82	1.14
		N80%	2797.94	10.66	7.44	3.22	3.81	2.66	1.15
		N60%	2797.94	7.86	5.67	2.19	2.81	2.03	0.78

CONCLUSION

From the obtained results it could be concluded that:

- Seasonal ET_0 during the growing season of winter wheat were 665.9 mm and 624.8 mm of 2015-2016 and 2016-2017 growing seasons, respectively.
- Wheat crop transpiration was 600.28 mm during the growing season of 2015- 02016 and changed to 572.95 mm for the next season.
- The gross irrigation water requirements of wheat were 2702.2 m^3/fed, 2792.6 m^3/fed and 2879.1 m^3/fed at $AWD_{45\%}$, $AWD_{60\%}$ and $AWD_{70\%}$ treatment for the growing season of 2015-2016, respectively, and became 2802.5 m^3/fed, 2687.4 m^3/fed and 2716.4 m^3/fed at the next growing season.
- Based on the irrigation regimes and water balance by the budget technique, the irrigation events of wheat at 45%, 60% and 70% depletion treatments were 29, 23 and 21, which required irrigating for 23.17, 23.94 and 24.69 hours in the first season, respectively. The second season results changed to 28, 23 and 20 irrigations, which required irrigating for 24.4, 22.96 and 23.29 hours.
- Among all the studied treatments, the maximum wheat grain yield and water use efficiency of wheat regardless of the variety under investigation could be obtained with irrigation at 60% depletion of the available soil moisture and 100% of the recommended nitrogen fertilization. The yield and grain water use efficiency of Giza 168 under these conditions were 2.78 ton/fed and 1.02 kg/m^3. While for Giza 171, 3.4 ton/fed and 1.24 kg/ m^3 were obtained with 22.3% and 21.6% increase in yield and grain water use efficiency, respectively.
- The results indicated a significant effect of the crop cultivars and nitrogen fertilization levels on biological yield, straw yield, grain yield, WUE of grain yield and WUE of straw yield. The irrigation water regime levels showed no significant effect on the previous parameters.
- The interaction of wheat cultivars, nitrogen fertilization levels and irrigation water regimes showed insignificant effect on biological yield, straw yield, grain yield, WUE of grain yield and WUE of straw yield.
- The water budget as an irrigation scheduling method is applicable in wheat irrigation in sandy soil.

Appendix I

$$R_a = 1.267 \left(\frac{h_d}{r_v^2} \right) \left[h_s \frac{\pi}{180} \sin \Phi \sin \delta + \cos \Phi \cos \delta \sinh_s \right]$$

$$h_d = 12.126 - 1.8519 \times 10^{-3} ABS(\Phi) + 7.61048 \times 10^{-5} (\Phi)^2$$

$$r_v = 0.9839 - 1.1140 \times 10^{-4} J + 5.277 \times 10^{-6} J^2 - 2.6829 \times 10^{-8} J^3 + 3.616 \times 10^{-11} j^{-4}$$

$$h_s = \cos^{-1} \left(-\tan^{-1} \Phi \tan \delta \right)$$

$$\delta = 23.45 \sin \left(360 \frac{284 + J}{365} \right)$$

$$\Delta = 2(0.00738 T_m + 0.8072)^7 - 0.00116$$

$$\gamma = \left[\frac{1615 P_a}{2.49 \times 10^6 - 2..13 \times 10^3 T_m} \right]$$

$$P_a = 1013 - 0.1152 h + 5.44 \times 10^{-6} h^2$$

$$R_n = 0.75 R_s - 2 \times 10^{-9} (T_m + 273.16)^4 (0.34 - 0.044 \sqrt{e_a}) \left(-0.35 + 1.8 \frac{R_s}{R_a} \right)$$

$$R_S = \left(0.25 + 0.5 \frac{n}{N} \right) R_a$$

$$f(u) = 0.27(1 + 0.01U)$$

$$e_s = 33.8639 \left[(0.00738 T_m + 0.8072)^8 - 0.000019 |1.8 T_m + 48| + 0.001316 \right]$$

$$e_a = e_s \left(\frac{RH_m}{100} \right)$$

where:

R_a Extraterrestrial solar radiation (mm/day) estimated according to James (1988).

h_d Daytime hours at zero declination, (hours)

r_v Radius vector of earth

h_s Sunrise to sunset hour angle (degrees), according to Duffie (1980)

Φ Latitude, (degrees)

δ Solar declination, (degrees), according to Duffie (1980)

J Julian day

Δ Slope of saturation vapor pressure versus temperature curve at mean temperature (mbar/C°) estimated according Cuneca (1989).

γ Psychometric constant (mbar/C°), according to James (1988).

P_a Atmospheric pressure, (mbar), according to James (1988).

h Elevation above sea level, m

R_s Solar radiation in evaporation equivalents (mm/day)

R_n Net radiation equivalent, (mm/day), according to Doorenbos and Pruitt (1977).

f(u) Wind function, according to Doorenbos and Pruirr (1977)

Δe Vapor pressure deficit (e_s - e_a), (mbar)

e_s Saturation vapor pressure at the air temperature, (mbar), according to Cuenca (1989)

Ea Vapor pressure at mean air temperature (mbar)

n/ Ratio of actual to maximum sunshine hours

N

Appendix II

Table (1): Effect of the interaction between studied factors on wheat Grain yield and Straw yield.

Wheat Cultivars	Fertilization	Irrigation Schedules	2015/2016			2016/2017		
			Biological yield	Grain yield	Straw yield	Biological yield	Grain yield	Straw yield
C1	1		9.17	2.65	6.52	8.99	2.62	6.38
	0.8		8.33	2.3	6.04	8.22	2.22	6
	0.6		6.54	1.88	4.67	6.52	1.87	4.65
C2	1		11.41	3.33	8.08	11.21	3.3	7.91
	0.8		10.57	3.08	7.49	10.48	3.05	7.43
	0.6		8.17	2.3	5.87	7.95	2.21	5.74
LSD$_{0.05}$			Ns	ns	ns	ns	*	Ns
C1		20%	8	2.28	5.71	7.83	2.25	5.58
C2			10	2.82	7.18	9.9	2.81	7.08
C1		25%	8.09	2.27	5.81	8.04	2.23	5.81
C2			10.23	3	7.23	9.93	2.9	7.03
C1		30%	7.96	2.27	5.7	7.87	2.23	5.64
C2			9.92	2.9	7.02	9.81	2.85	6.96
LSD$_{0.05}$			Ns	ns	ns	ns	ns	Ns
	1	20%	10.35	3.02	7.33	9.94	2.95	7
	0.8		9.16	2.51	6.65	9.09	2.49	6.6
	0.6		7.49	2.13	5.36	7.55	2.15	5.4
	1	25%	10.56	3.11	7.45	10.4	3.07	7.33
	0.8		9.64	2.77	6.86	9.43	2.66	6.77
	0.6		7.28	2.02	5.26	7.12	1.96	5.16
	1	30%	9.96	2.85	7.11	9.95	2.84	7.11
	0.8		9.56	2.79	6.78	9.53	2.77	6.77
	0.6		7.3	2.11	5.18	7.04	2.01	5.03
LSD$_{0.05}$			Ns	*	ns	ns	*	Ns

Wheat Cultivars	Fertilization	Irrigation						
C1	1	20%	9.29	2.67	6.63	8.95	2.6	6.35
	0.8		8	2.24	5.75	7.79	2.19	5.6
	0.6		6.7	1.94	4.76	6.73	1.95	4.78
C2	1		11.41	3.37	8.04	10.93	3.3	7.63
	0.8		10.32	2.77	7.54	10.39	2.79	7.6
	0.6		8.28	2.32	5.97	8.36	2.34	6.02
C1	1	25%	9.39	2.8	6.57	9.19	2.76	6.43
	0.8		8.54	2.3	6.25	8.47	2.17	6.3
	0.6		6.36	1.73	4.63	6.46	1.76	4.7
C2	1		11.75	3.43	8.33	11.62	3.39	8.23
	0.8		10.73	3.25	7.48	10.39	3.14	7.24
	0.6		8.2	2.31	5.97	7.79	2.17	5.62
C1	1	30%	8.86	2.5	6.36	8.84	2.49	6.35
	0.8		8.47	2.35	6.12	8.41	2.31	6.1
	0.6		6.57	1.96	4.61	6.37	1.89	4.48
C2	1		11.07	3.2	7.87	11.07	3.2	7.87
	0.8		10.66	3.23	7.44	10.66	3.23	7.44
	0.6		8.02	2.27	5.76	7.7	2.12	5.58
$LSD_{0.05}$			Ns	ns	ns	ns	ns	Ns

ns: not significant based on $LSD_{0.05}$.

Table (2): Effect of wheat cultivars, fertilization and irrigation regime on water use efficiency.

Wheat Cultivars	Fertilization	Irrigation	2015/2016		2016/2017	
			WUE	WUE	WUE	WUE
			Kg G/ m³	Kg S/ m³	Kg G/ m³	Kg S/ m³
C1	1		0.95	2.34	0.96	2.33
	0.8		0.82	2.16	0.81	2.2
	0.6		0.67	1.67	0.68	1.7
C2	1		1.2	2.9	1.21	2.9
	0.8		1.1	2.68	1.12	2.72
	0.6		0.82	2.11	0.81	2.1
$LSD_{0.05}$			ns	ns	*	Ns
C1		20%	0.85	2.11	0.8	2
C2			1.04	2.66	1	2.53
C1		25%	0.81	2.08	0.83	2.17
C2			1.07	2.59	1.08	2.63
C1		30%	0.79	1.98	0.82	2.08
C2			1.01	2.44	1.05	2.56
$LSD_{0.05}$			ns	ns	ns	Ns

Group	Ratio	%	V1	V2	V3	V4
	1		1.12	2.71	1.05	2.5
	0.8	20%	0.93	2.46	0.89	2.36
	0.6		0.79	1.98	0.77	1.93
	1		1.11	2.67	1.15	2.74
	0.8	25%	0.99	2.46	0.99	2.53
	0.6		0.72	1.88	0.73	1.93
	1		0.99	2.47	1.05	2.62
	0.8	30%	0.97	2.35	1.02	2.49
	0.6		0.73	1.8	0.74	1.85
$LSD_{0.05}$			*	ns	*	Ns
C1	1		0.99	2.45	0.93	2.27
	0.8		0.83	2.13	0.78	2
	0.6	20%	0.72	1.76	0.7	1.71
C2	1		1.25	2.97	1.18	2.72
	0.8		1.03	2.79	1	2.71
	0.6		0.86	2.21	0.84	2.15
C1	1		1	2.35	1.03	2.4
	0.8		0.82	2.24	0.81	2.35
	0.6	25%	0.62	1.66	0.66	1.76
C2	1		1.23	2.98	1.26	3.07
	0.8		1.16	2.68	1.17	2.71
	0.6		0.83	2.11	0.81	2.1
C1	1		0.87	2.21	0.92	2.34
	0.8		0.82	2.12	0.85	2.25
	0.6	30%	0.78	1.6	0.7	1.65
C2	1		1.11	2.73	1.18	2.9
	0.8		1.12	2.58	1.19	2.74
	0.6		0.79	2	0.78	2.05
$LSD_{0.05}$			ns	ns	ns	Ns

ns: not significant based on $LSD_{0.05}$.

DEDICATION

We dedicate this work to the spirit of Dr. Khalil Allam who started this work and then died in a terrible accident while performing his duty in Sinai.

<u>REFERENCES</u>

Abdelmageed, K., CHANG, X. H., WANG, D. M., WANG, Y. J., YANG, Y. S., ZHAO, G. C. and Z. Q. TAO (2019). Evolution of varieties and development of production technology in Egypt wheat: A review. *J. Integr. Agri.*, 18(3): 483-495.

Abdelraouf, R. E., M. E. Ahmed, B. A. Bakry and M. KH. Elbegawy (2014). Effect of Sprinkler Irrigation Systems and Irrigation Frequency on Water Use Efficiency and Economical Parameters for Wheat Production. *International Journal of Scientific Research in Agricultural Sciences*, 1(4): 56-66.

Adeboye, O., B. Schultz, K. Adekalu and K. Prasad (2015). Crop water productivity and economic evaluation of drip-irrigated soybeans (*Glyxine max* L. Merr.). *Agriculture and Food Security*, 4(10): 1-13.

Allen, R. G., Pereira, L. S., Raes, D. and M. Smith (1998). Crop evapotranspiration-Guidelines for computing crop water requirements. *FAO Irrigation and drainage paper 56*. FAO, Rome, 300(9), p.D05109.

ASAE 1988: Engineering Practices and Data Adopted by the American Society of Agricultural Engineers, Volume 2002. The University of Wisconsin – Madison.

Berry, A. M., G. A. Sharaf, Azza Hassan and Ebtsam Sebaaee (2004). Irrigation scheduling of sunflower with drip irrigation system in newly reclaimed land. *Misr J. Ag. Eng.,* 20(4): 993-1010.

Black, C. A., D. D. Evans, L. E. Ensminger, J. L. White, F. E. Clark and R. C. Dinauer (1982). Methods of soil analysis. 7th Ed. *The Am. Soc. of Agron*. Madison, Wisc., USA

CoHort Software (2005). Costat Statistical package (version 6.311), P.O.Box 1149, Berkeley, CA, 94701, USA.

Cuenca, R. H. (1989). Irrigation System Design: An Engineering Approach. Prentice Hall, pp552.

Doorenbos, J. and W.O. Pruit (1977). Guidelines for predicting crop water requirements FAO, i*rrigation and drainage paper No. 24.* FAO, United Nation, Rome.

Duffie, J. A. and W. A. Beckman, (1980). Solar engineering of thermal processes, John Wiley, Sons; New york.

Duke, H. R., G. W. Buchleiter and D. F. Heermann (1985). Evapotranspiration Theory USDA Agric. Res. Service: 11.

El-Kholy, M. A., S. A. Ouda, M. S. Gaballah and M. Hozayn (2005). Predicting the interaction between the effect of anti-transpirant and weather on productivity of wheat plant grown under water stress. *Journal of Agronomy,* 4: 75-82.

Faostat, F.A.O. (2017). FAO open data. Available online at: *FAO web site* http://www.fao.org/faostat/en/#data, accessed on January 2018.

James, L. M. (1988). Principles of farm irrigation system design. John Wiley Sons: 543 pp.

Jensen, M. E. (1983). Design and operation of farm irrigation systems. Am. Soc. Ag. Eng. Joseph, Michigan.: pp819-820.

Kayam, Y., Beyazgül, M. and A. Yazar (2000). Use of Infrared Thermometer Technique in Irrigation Scheduling of Cotton Plant. *Soil and Water Resources Research*, pp. 312–326.

Noreldin, T., S. Ouda, O. Mounzer and M. T. Abdelhamid (2015). CropSyst model for wheat under deficit irrigation using sprinkler and drip irrigation in sandy soil. *Journal of Water and Land Development,* 26: 57–64.

Odemiş, B. and R. Bastug (1999). Assessing crop water stress and irrigation scheduling in cotton through use of infrared thermometry technique. *Turk. J. Agric. For*. 23: 31–37.

World Bank, T. (2018). World Bank open data. Available online at: *World Bank Web site* https://www.worldbank.org/, accessed on June 2019.

<u>الملخص العربي</u>

تأثر إنتاجية محصول القمح
بحدود جدولة الري ومستويات التسميد النيتروجينى

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أجريت الدراسة الحالية بمنطقة بحري الميثاق بمنطقة برج العرب غرب الاسكندرية، وكان الغرض من إجراء هذا البحث هو دراسة تأثير مستويات مختلفة من جدولة الرى والتسميد النيتروجينى على إنتاجية محصول القمح. وأجريت الدراسة على صنفين من القمح جيزة ١٦٨ وجيزة ١٧٢. وتم تحديد مواعيد الرى وكميات مياه الرى عند مستويات رطوبة محددة عند إستنفاذ ٤٥% و٦٠% و٧٠% من قيمة الماء المتاح في التربة عند السعة الحقلية وعند مستويات تسميد ١٠٠% و٨٠% و٦٠% من مستويات التسميد النيتروجينى الموصى بها. والطريقة المتبعة فى جدولة الرى وتحديد كميات المياه المطلوبة وزمن التشغيل لنظام الرى بالرش هى الاتزان المائى. وأجريت الدراسة لموسمين شتويين متتاليين وهما ٢٠١٥-٢٠١٦ و٢٠١٦-٢٠١٧. وأظهرت النتائج تفوق صنف جيزة ١٧٢ فى الانتاجية على صنف جيزة ١٦٨ بحوالى ٢٢،٣%. وأثبتت الدراسة أنه للحصول على أقصى إنتاجية من محصول القمح تحت ظروف التجربة هو الرى عند إستنفاذ ٦٠% من الماء المتاح في التربة مع التسميد النيتروجينى بمعدل ١٠٠% من الكمية الموصى به والمتبع حاليا. وكان إجمالى مياه الرى عند المستويات الثلاث من جدولة الرى هو ٢٠٠٢،٢ م٣/فدان و٢٧٩٢،٦ م٣/فدان و ٢٨٧٩،١ م٣/فدان فى الموسم الاول لتصبح ٢٨٠٢،٥ م٣/فدان و ٦٨٧،٤ م٣/فدان و ٢٧١٦،٤ م٣/فدان فى الموسم التالى. كما أظهرت النتائج ان المحصول القياسى لصنف جيزة ١٦٨ هو ٢،٧٨ طن/فدان مع كفاءة استخدام المياه مقدارها ١،٠٢ كج/م٣ فيما انتج صنف جيزة ١٧٢ محصول حبوب مقداره ٣،٤ طن/فدان مع كفاءة استخدام المياه مقدارها ١،٢٤ كج/م٣.

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