*J.Soil Sci. and Agric. Eng., Mansoura Univ., Vol. 8 (10): 521 - 529, 2017*

# Water Productivity of Wheat Crop as Affected by Different Sowing Dates and Deficit Irrigation Treatments

**Taha, A. A.[1]; M. A. Ibrahim[2]; A. M. Mosa[1] and M. N. EL-Komy[2]**
**[1] Soil S. Dept., Fac. of Agric., Mansoura Univ., Egypt.**
**[2] Soils, Water and Environment Res. Inst., A.R.C., Egypt.**
***Part of Ph.D. Thesis, Soil Sci. Dept., Fac. of Agric., Mansoura Univ., Egypt.**

## ABSTRACT

Climate change scenarios require reconsidering different agricultural practices including sowing dates and irrigation intervals. For this purpose, a field experiment was carried out at the Agricultural Research Farm of Sakha Agricultural Research Station, Kafr-Elsheikh Governorate during the successive winter seasons 2013/2014 and 2014/2015 to investigate the impact of deficit water irrigation and sowing dates on wheat crop productivity(*Triticum aestivum* L.). The experimental site located at latitude of 30°: 37¯N, longitude of 31 ° - 57¯E, and altitude of +6 meters above the sea level. The experimental design was split – plot with three replicates. The main plot was assigned to sowing dates of 15$^{th}$ November ($S_1$) , 30$^{th}$ November ($S_2$) and 15$^{th}$ December ($S_3$), while the sub plot was assigned to irrigation treatments i.e. $I_1$ (given four irrigations plus the sowing irrigation, $I_2$ (given three irrigations following the sowing irrigation) and $I_3$ (given two irrigations after the sowing irrigation). The highest mean values of water applied (Wa) and consumptive use (CU) were 613.6 and 485.6 mm under treatment $S_1I_1$ , respectively. While the corresponding lowest mean values were 363.3 and 310.4 mm under treatment $S_3I_3$ . The highest contribution percentages of rainfall to water applied (Wa) were 46.6% and 38.4 % for treatments $S_3I_3$ under third sowing date in the first season. While, in the second season were 43.4% and 35.7% for treatments $S_2I_3$ under the two sowing date, respectively. The lowest contribution percentages were 27.3%, 31.7 % and 27.8% , 32.4% for treatment $S_1I_1$ under first sowing date in two seasons. Moreover, the highest mean values of grain water productively ($WP_g$), straw water productively ($WP_s$) were recorded under $S_1$ and $I_3$ in the first season with values of 1.47, 1.48, 2.27 and 2.19 kg $m^{-3}$, respectively. While in the second season the highest values were recorded under $S_2$ and $I_3$ with values 1.7, 1.59, 2.31 and 2.41 kg $m^{-3}$, respectively. The highest mean values of productivity of water applied for grain and straw (PWag , PWas ) were recorded under $S_2$, $I_3$, in two growing seasons with values of 1.17, 2.23, 1.39, 1.33,1.82, 1.89, 1.97 and 1.92 kg $m^{-3}$, respectively. In addition, biological yield, grain yield, straw yield, plant height and 1000-grain weight given the highest values under $S_1I_1$ , $S_2I_1$ in the two seasons.

**Keywords:** *Wheat crop, water deficit, sowing date, Crop consumptive use, water productivity and productivity of water applied*

## INTRODUCTION

In the recent decades, Egypt is facing a serious crisis in the available water supplies due to the rapid growth population alongside with the stability of fresh water resources. On the other hand, the expected adverse impacts of climate change scenarios might cause additional threat to our future water planning. All stated factors resulted in decreasing the capital share of water to be less than the water poverty limit (1000 $m^3$ per annum), and it is expected to reach the water scarcity level of less than 500 $m^3$ in the few coming decades. At such circumstances, it is very difficult to make any progress with different national economic sector of development. Therefore, it is strongly recommended to look for sustainable management practices to improve crop yield productivity (particularly economic crops) under these environmental threats.

Wheat is the main strategic cereal crop in Egypt and worldwide. Production of wheat in Egypt is less than the consumption of the nations. It is the most important staple food of about two billion people (36% of the world population). Worldwide, wheat provides nearly 55% of the carbohydrates and 20% of the food calories consumed globally (Breiman and Graur, 1995). It is one of the most widely consumed cereal crops grown globally under different environmental conditions. Therefore, increasing of crop productivity from each unit of water and soil becomes a must. As cities grow and populations increase, the problem worsens since needs for water increase in households, industry and agriculture. Deficit irrigation is profitable when the revenue lost due to yield reduction is less than the savings in costs of production due to applying less than the required water. The impact of water stress on yields and economic returns depend upon the irrigation system, the performance of that system, production costs, and the type of crop. *Moussa and Abdel-Maksoud (2004*) stated that irrigated wheat crop with 40-45 % ($I_1$), 60-65 % ($I_2$) and 80-85 % ($I_3$) from the available soil moisture resulted in decreasing water use efficiency as 427.6, 375.3 and 279.4 mm/ season for I1, I2 and I3 irrigation treatments, respectively.

Sowing date also plays vital role in the water use efficacy. *Ouda et al.(2005*) studied six sowing dates (1st of October, 15th of October, 1st of November, 15th of November, 1st of December, and 30th of December) on wheat yield (Sakha 93), in addition to water stress at different growth stages. Results indicated that wheat sowing date in October reduced grain yield by about 10%. Whereas, delay of sowing date till the end of December decreased yield by about 16%. The highest grain yield was obtained when wheat was sown on the first of December, followed by 15th of November, compared with other sowing dates.

Several reports investigated the effect of sowing date on water use efficiency. According to Xue *et al*. (2006) deficit irrigation increased WUE of wheat. Also, Zhang *et al*. (2005) and Rezgui (2014) showed that WUE is higher under supplemental irrigation with 60% of maximum Evapotranspiration (2.2 kg grains $m^{-3}$) compared to supplemental irrigation with 90% ETM (1.95 kg grains $m^{-3}$). Also, Rezgui *et al*. (2005) showed that irrigation increased WUE of Durum wheat in the semi-arid region of Tunisia from 0.86 kg grains $m^{-3}$ to 1.24 grains $m^{-3}$, respectively for rainfed and irrigation with 90% ETM.

Cheikh M'hamed *et al* (2015) indicated that irrigation affect considerably the daily water consumption, cumulative water consumption, total dry matter, grain yield and WUE. However, this effect was variable between cropping seasons and treatments tested ($D_1$, $D_2$, $D_3$ and $D_4$ water regimes). The cumulative water consumption increased gradually, with increasing irrigation levels. The relationship between total dry matter and water consumption was linearly regression with high correlation coefficient. WUE compared to TDM (WUE-TDM) of wheat decreased with increase of irrigation levels and the higher WUE-TDM was obtained under rainfed condition (D4).However, contrary result was recorded for WUE compared to grain yield (WUE-GY). The irrigation increase WUE-GY and the highest value was obtained under moderate irrigation.

Therefore the main objectives of this study are to find out the interaction effects of different sowing dates and water deficit particularly on water productivity of wheat crop. In addition, crop water functions should be determined owing to produced more crops per less water.

# MATERIALS AND METHODS

A field experiment was carried out during the two wheat growing seasons of 2013/2014 and 2014/2015 at Sakha Agricultural Research Station. The site is located at North Nile Delta with 30°-57' N latitude, 31°-07'E longitude and altitude of about +6 meters above the sea level. Climatic elements of the area during the two growing seasons are presented in Table 1. The climatic data was recorded by Sakha Agro climatic Station.

**Table 1. Mean of climatic elements of air temperature (°C), mean relative humidity (RH, %), wind speed ($U_2$, $m.sec^{-1}$), evaporation pan (Ep, $mm.d^{-1}$) and rainfall (Rf, mm $month^{-1}$) during the two wheat growing seasons.**

| Month | T,C° | | | RH, % | $U_2$, $m.sec^{-1}$ | Ep, $mm.d^{-1}$ | Rf, mm |
|---|---|---|---|---|---|---|---|
| | Max | Min | Mean | | | | |
| | | | Season 2013/2014 | | | | |
| Nov.2013 | 25.39 | 15.14 | 20.27 | 75.72 | 0.80 | 2.28 | 0.00 |
| Dec.2013 | 19.64 | 8.51 | 14.08 | 79.84 | 0.61 | 4.15 | 81.90 |
| Jan.2014 | 20.34 | 7.55 | 13.95 | 80.55 | 0.54 | 1.60 | 20.70 |
| Feb.2014 | 20.64 | 8.19 | 14.42 | 79.53 | 0.79 | 2.52 | 16.50 |
| Mar.2014 | 22.94 | 11.71 | 17.33 | 71.45 | 0.96 | 3.14 | 26.20 |
| Apr.2014 | 27.50 | 15.53 | 21.52 | 65.80 | 1.07 | 4.91 | 20.20 |
| Seasonal | 22.74 | 11.11 | 16.93 | 75.48 | 0.80 | 3.10 | 165.50 |
| | | | Season 2014/2015 | | | | |
| Nov.2014 | 24.30 | 13.79 | 19.05 | 74.15 | 0.78 | 2.77 | 24.60 |
| Dec.2014 | 22.27 | 9.72 | 16.00 | 76.05 | 0.53 | 1.72 | 5.70 |
| Jan.2015 | 18.79 | 6.46 | 12.63 | 74.60 | 0.82 | 2.70 | 52.55 |
| Feb.2015 | 19.01 | 7.65 | 13.33 | 74.75 | 0.84 | 2.90 | 38.80 |
| Mar.2015 | 22.69 | 11.69 | 17.19 | 70.59 | 1.01 | 3.23 | 15.25 |
| Apr.2015 | 25.64 | 13.70 | 19.67 | 63.40 | 1.11 | 6.07 | 35.85 |
| Seasonal | 22.12 | 10.50 | 16.31 | 72.26 | 0.85 | 3.23 | 172.75 |

**1- Physical and chemical properties of the soil:-**

Soil samples from different depths (0-15 cm), (15-30 cm), (30- 45 cm) and (45-60cm) were taken from the studied site. Soil- water constant such as soil field capacity (F.C) and wilting point were determined according to *James (1988)* and The bulk density was determined according to *Klute, (1986)*.The soil texture, the particle size distribution was determined according to the International method (*Klute, 1986)*. The obtained results indicated that the soil texture is clayey as shown in Table 2. Chemical properties such as total soluble salts (soil Ec, dS $m^{-1}$), soil reaction (pH), both soluble cations and anions were determined according to the methods described by *(Jackson, 1973)*. $So_4^{2-}$ was calculated by the difference between soluble cations (meq $L^{-1}$) and anions (meq$L^{-1}$) as tabulated in Table 2.

**2- Agronomic practices**

Wheat (*Triticum aestivum* L.) Variety Misr 2 was cultivated. All agronomic practices for wheat crop in the studied area were implemented based on the recommendations of the Agricultural Research Center (ARC) except the studied treatments (irrigation treatments and sowing dates). The experimental design was a split- plot with three replicates where the main plots were sowing dates and subplots was irrigation treatments as follows:

**The main plots (sowing dates):**

$S_1$= sowing date on 15th November.
$S_2$= sowing date on 30th November.
$S_3$= sowing date on 15th December.

The sub main plots (irrigation treatments):

$I_1$ = four irrigations following sowing irrigation
$I_2$ = three irrigations following sowing irrigation
$I_3$ = two irrigations following sowing irrigation.

**Statistical design and analyses:**

All statistical analyses were performed with Co-stat (version 6.3030 and Microsoft Office Excel 2010 programs.

**3- Data collection**

**a.Water parameters:**

**1- Irrigation water (IW)**

Irrigation water was measured by contracted rectangular weir (Michael, 1978):

$$Q = 0.0184(L - 0.2H)\, H^{1.5}$$

**In which**
**Q = discharge, litre/second**
**L = length of crest, cm**
**H = head over the crest, cm**.

**2- Effective rainfall ($Rf_e$)**

Effective rainfall ($Rf_e$) was computed as rainfall multiply by 0.7 (*Novica, 1979*).

**3- Water applied (Wa)**

Water applied equaled irrigation water (IW) plus total rainfall (∑ Rf).

**4- Water Consumptive use (CU)**

Actual water consumptive use (CU) or so-called crop evapotranspiration ($ET_c$) was determined based on soil moisture depletion in the effective root zone of 60 cm as follows *(Hansen et al., 1979)*:

$$Cu = \frac{FC - \Theta}{100} * \frac{Db}{Dw} * d$$

**Where:**

**CU = consumptive use or actual crop water consumed, cm.**
**FC = soil moisture content on weight basis at field capacity**
**Θ = soil moisture content on the weight basis before irrigation**
**Db = bulk density ($kg.m^{-3}$)**
**Dw = density of water ($kg.m^{-3}$)**
**d = effective root zone of 60 cm.**

It should be notified that soil moisture depletion included the effective rainfall $Rf_e$ as described before.

**3- Crop-water functions**

**1- Water productivity (WP):**

Water productivity as defined by *Bos (1980)* is the parameter of crop-water functions which reflects the capability of crop water consumed in producing marketable yield as follows:

**WP = Y/CU**

**Where**:

**WP = water productivity ($kg.m^{-3}$ water consumed)**
**Y = marketable yield (kg) for grain and straw**
**CU = crop-water consumption ($m^3$).**

**2- Productivity of water applied (PWa, kg $m^{-3}$):**

Productivity of water applied (PWa) was calculated according to *Ali et al.* (2007*)*.

**PWa = Y/ Wa**

**Where:**

**PWa = productivity of water applied (kg $m^{-3}$)**
**Y = yield (kg $fed^{-1)}$ for grain and straw**
**Wa = water applied ($m^3$. $fed^{-1}$) where equal irrigation water (IW) ($m^3$. $fed^{-1}$ or mm) plus rainfall (Rf) ($m^3$. $fed^{-1}$ or mm)**

**3- Vegetative, yield and yield components:**

1- Plant height at harvest, cm.
2- 100 grain weight, gm.
3- Biological yield, kg $fed^{-1}$.
4- Grain yield, kg $fed^{-1}$.
5- Straw yield, kg $fed^{-1}$.
6- Harvest index, %.

**Harvest index = (grain yield / Biological yield)*100**

**Table 2. Some physical and chemical properties of the studied experimental soil:**

| Some Physical properties | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Soil Depth, cm. | Particle Size Distribution | | | Texture Class | F.C % | W.P % | AW (%) | Bd, mg $m^{-3}$ |
| | Sand% | Silt % | Clay % | | | | | |
| 0 – 15 | 15.70 | 31.00 | 53.30 | Clay | 44.61 | 26.56 | 18.05 | 1.04 |
| 15 – 30 | 22.40 | 33.10 | 44.50 | Clay | 40.20 | 21.44 | 18.76 | 1.09 |
| 30 – 45 | 20.70 | 40.30 | 39.00 | Clay loam | 38.70 | 20.60 | 18.10 | 1.11 |
| 45 – 60 | 22.90 | 40.90 | 36.20 | Clay loam | 36.30 | 19.83 | 16.47 | 1.16 |
| Mean | 20.43 | 36.33 | 43.25 | Clay loam | 39.95 | 22.11 | 17.85 | 1.10 |

| Soil Depth, Cm | Ec, $dSm^{-1}$ in soil paste extract | pH (1: 2.5) soil water suspension | Some chemical properties | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Soluble ions, meq $l^{-1}$ | | | | | | | |
| | | | Cations | | | | Cations | | | |
| | | | $Ca^{2+}$ | $Mg^{2+}$ | $Na^+$ | $K^+$ | $CO_3^{2-}$ | $HCO_3^-$ | $Cl^-$ | $SO_4^{2-}$ |
| 0-15 | 1.83 | 8.65 | 7.31 | 2.18 | 8.70 | 0.22 | N.D | 4.30 | 9.00 | 5.11 |
| 15-30 | 2.45 | 8.54 | 9.54 | 5.10 | 9.60 | 0.19 | N.D | 3.90 | 8.90 | 11.63 |
| 30-45 | 2.56 | 8.49 | 9.67 | 5.47 | 10.02 | 0.18 | N.D | 3.70 | 7.80 | 13.84 |
| 45-60 | 3.01 | 8.37 | 11.50 | 6.28 | 12.00 | 0.17 | N.D | 3.60 | 7.00 | 19.35 |
| Mean | 2.46 | | 9.51 | 4.76 | 10.08 | 0.19 | N.D | 3.88 | 8.18 | 12.48 |

**Where: - F.C % = Soil field capacity, W.P % = wilting point, AW % = Available water, and Bd, Mg/m³ = Soil bulk density, N.D. means not detected**

## RESULTS AND DISCUSSION

**A – Water parameters**

**1 – Effective rainfall ($Rf_e$)**

Values of seasonal rainfall as tabulated in Table 3 and illustrated in Fig. 1 clear out that rainfall in the studied area from November through April. Meaningfully, rainfall is distributed among the wheat growing season. This situation is considering rainfall as a main component of water applied to such winter crop of wheat. Mean values of rainfall during the studied seasons can be arranged in descending order as 43.80, 36.63, 28.03, 27.65, 20.73 and 12.30 mm for December, January, April, February, March and November, respectively. In general, seasonal rainfall is in average of 169.13 mm or 710.35 $m^3$ $fed^{-1}$, which is partially water, needs to meet some winter crops such as wheat.

Therefore, in this direction, effective rainfall ($Rf_e$) or the useful portion of rainfall used in crop water consumption, which equaled rainfall multiply by 0.7 took the same trend as total rainfall (*Novica, 1979*).

This fact is explained by *Allen (1991)* who pointed out that not all rainfall is effective in fulfilling irrigation water requirements for these reasons:

1. Surface runoff due to high rainfall intensity, low infiltration rates or frozen soil.
2. Deep percolation from heavy rainfall occurring immediately following an irrigation or previous rainfall event.
3. Evaporation of intercepted rain on plant leaves.

**2 - Water applied (Wa, $m^3$ $fed^{-1}$ & mm)**

Under the conditions of the present study, the seasonal water applied (Wa) consists of two components; irrigation water (IW) and rainfall (Rf) which are presented in Table 3 and Fig 1. During the two seasons of study, wheat as a winter crop received rainfall of 165.5 mm and 172.8mm, which equal 695.1 and 725.35 $m^3.fed^{-1}$, respectively. Water applied (Wa) decreased with decreasing number of irrigations, which means that Wa has the same trend with number of irrigations, the high number of irrigations is the high amount of water applied. The highest values of contribution percentages of rainfall to water applied (Wa) were 46.6% and 38.4 % for treatments $S_3I_3$ under third sowing date in the first season. While, in the second season were 43.4% and 35.7% for treatments $S_2I_3$ under two sowing date, respectively. While the lowest contribution percentages were 27.3%, 31.7 % and 27.8% , 32.4% for treatment $S_1I_1$ under first sowing date ($S_1$) in general in the two growing seasons, respectively.

Therefore, the highest Wa was associated with the first sowing date ($S_1$) and the maximum irrigation number ($I_1$). The values were 2195.5, 2300.1 and 2216.9, 2447.1 $m^3$ $fed^{-1}$ in the two seasons, respectively. The obtained results are in the same direction with that reported by chen *et al* (2014).

**Table 3. seasonal water applied (Wa), irrigation water (IW) and rainfall (Rf) for wheat**

| Season Treatment | | 1st season Wa. | IW | Rf. | 2nd season Wa. | IW | Rf. | Mean Wa. | | IW | | Rf. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $m^3fed^{-1}$ | $m^3fed^{-1}$ | $m^3fed^{-1}$ | $m^3fed^{-1}$ | $m^3fed^{-1}$ | $m^3fed^{-1}$ | m3 $fed^{-1}$ | mm | $m^3fed^{-1}$ | Mm | $m^3fed^{-1}$ | Mm |
| | $I_1$ | 2545.4 | 1850.3 | 695.1 | 2608.9 | 1883.3 | 725.6 | 2577.2 | 613.6 | 1866.8 | 444.5 | 710.4 | 169.1 |
| $S_1$ | $I_2$ | 2194.1 | 1499 | 695.1 | 2212.6 | 1487 | 725.6 | 2203.4 | 524.6 | 1493 | 355.5 | 710.4 | 169.1 |
| | $I_3$ | 1846.9 | 1151.8 | 695.1 | 1893.4 | 1167.8 | 725.6 | 1870.2 | 445.3 | 1159.8 | 276.1 | 710.4 | 169.1 |
| | $I_1$ | 2234.5 | 1539.4 | 695.1 | 2438.7 | 1713.1 | 725.6 | 2336.6 | 556.3 | 1626.3 | 387.2 | 710.4 | 169.1 |
| $S_2$ | $I_2$ | 1916.6 | 1221.5 | 695.1 | 1976.1 | 1250.5 | 725.6 | 1946.4 | 463.4 | 1236 | 294.3 | 710.4 | 169.1 |
| | $I_3$ | 1613.9 | 918.8 | 695.1 | 1673.4 | 947.8 | 725.6 | 1643.7 | 391.3 | 933.3 | 222.2 | 710.4 | 169.1 |
| | $I_1$ | 2120.5 | 1425.4 | 695.1 | 2293.7 | 1671.5 | 622.2 | 2207.1 | 525.5 | 1548.4 | 368.7 | 658.7 | 156.8 |
| $S_3$ | $I_2$ | 1820.3 | 1125.2 | 695.1 | 1879.8 | 1257.6 | 622.2 | 1850.1 | 440.5 | 1191.4 | 283.7 | 658.7 | 156.8 |
| | $I_3$ | 1490.9 | 795.8 | 695.1 | 1560.4 | 938.2 | 622.2 | 1525.7 | 363.3 | 867.0 | 206.4 | 658.7 | 156.8 |

**Table 4. Irrigation water applied in ($m^3fed^{-1}$) as related to interaction between sowing date and irrigation treatments.**

| Seasons | 1st season | | | | 2nd season | | | | Mean | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Treatments | $S_1$ | $S_2$ | $S_3$ | I-mean | $S_1$ | $S_2$ | $S_3$ | I-mean | $S_1$ | $S_2$ | $S_3$ | I-mean |
| $I_1$ | 2545.4 | 2234.5 | 2120.5 | 2300.1 | 2608.9 | 2438.7 | 2293.7 | 2447.1 | 2577.2 | 2336.6 | 2207.1 | 2373.6 |
| $I_2$ | 2194.1 | 1916.6 | 1820.3 | 1977 | 2212.6 | 1976.1 | 1879.8 | 2022.8 | 2203.4 | 1946.4 | 1850.1 | 2000.0 |
| $I_3$ | 1846.9 | 1613.9 | 1490.9 | 1650.6 | 1893.4 | 1673.4 | 1560.4 | 1709.1 | 1870.2 | 1643.7 | 1525.7 | 1679.9 |
| S-mean | 2195.5 | 1921.7 | 1810.6 | | 2238.3 | 2029.4 | 1911.3 | | 2216.9 | 1975.6 | 1861.0 | |

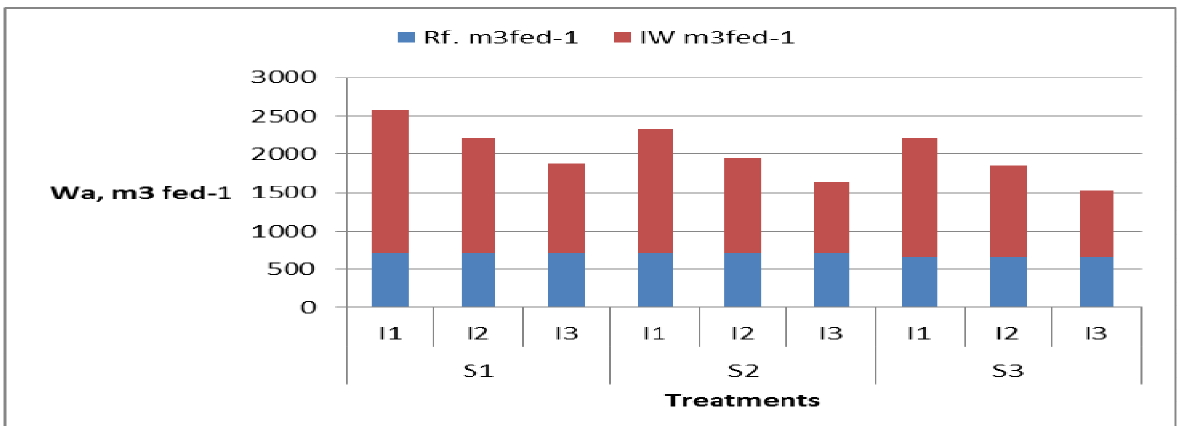


**Fig. 1. Mean of the two seasons for water applied ($m^3$ $fed^{-1}$) which included irrigation water and rainfall as affected by sowing dates and irrigation treatments for wheat**

**3. Crop consumptive use (CU):**

The amount of crop water consumptive use (CU) represents the useful portion of water applied in growing the cultivated crops and ultimately in crop production. Crop consumptive use (CU) was determined directly from the soil moisture depletion (S.M.D) in the effective root zone. Values of seasonal CU in $m^3fed^{-1}$ and mm are presented in Tables (5and 6) and the mean CU illustrated in Fig (2) for wheat during the two growing seasons. The obtained results showed that the seasonal CU values were greatly affected by number of irrigations, which increased with increasing the irrigation number particularly under the same effective rainfall ($Rf_e$) used by the irrigation treatments under each sowing date. Mean seasonal values of CU were, 1979.29, 1594.79 and 1395.7 $m^3$ $fed^{-1}$ for treatments $I_1$, $I_2$, and $I_3$, respectively. Results in Tables (5&6) showed that values of the CU were higher under $S_1$ than other sowing dates. Mean values of CU, were 1761.11, 1630.01 and 1578.66 $m^3$ $fed^{-1}$

for $S_1$, $S_2$ and $S_3$, respectively. Average CU rate could be arranged in descending order as; 2.5, 2.3 and, 2.32 mm day$^{-1}$ for treatments $S_3$, $S_2$and $S_1$, and 2.86, 2.3 and 2.01 mm day$^{-1}$ for treatments $I_1$, $I_2$ and $I_3$, respectively. These results agreed with that obtained by *Moussa and Abdel-Maksoud (2004*), *Khalil et al. (2007)* and Cheikh M'hamed *et al* (2015) who reported that The CU was increased with increasing irrigation levels.

**Table 5. Seasonal crop consumptive use (CU) and daily rate for wheat as affected by sowing dates and irrigation treatments in the two growing seasons.**

| Season | | 1st season | | | | 2nd season | | | | Mean | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Treatment | | CU | | Period (day) | Rate, mm day$^{-1}$ | CU | | Period (day) | Rate, mm day$^{-1}$ | CU | | Period (day) | Rate, mm day-$^{1}$ |
| | | m$^3$fed$^{-1}$ | mm | | | m$^3$fed$^{-1}$ | mm | | | m$^3$fed$^{-1}$ | mm | | |
| | $I_1$ | 2031.13 | 483.6 | | 2.78 | 2047.81 | 487.57 | | 2.61 | 2039.47 | 485.59 | | 2.69 |
| $S_1$ | $I_2$ | 1709.39 | 407.0 | 174 | 2.34 | 1732.42 | 412.48 | 187 | 2.21 | 1720.91 | 409.74 | 180.5 | 2.27 |
| | $I_3$ | 1495.42 | 356.05 | | 2.05 | 1550.47 | 369.16 | | 1.97 | 1522.95 | 362.61 | | 2.01 |
| | $I_1$ | 1954.74 | 465.41 | | 2.93 | 1970.13 | 469.08 | | 2.73 | 1962.44 | 467.25 | | 2.82 |
| $S_2$ | $I_2$ | 1553.44 | 369.87 | 159 | 2.33 | 1580.63 | 376.34 | 172 | 2.19 | 1567.04 | 373.10 | 165.5 | 2.25 |
| | $I_3$ | 1330.53 | 316.79 | | 1.99 | 1390.56 | 331.09 | | 1.92 | 1360.55 | 323.94 | | 1.96 |
| | $I_1$ | 1931.21 | 459.81 | | 3.19 | 1940.68 | 462.07 | | 1.94 | 1935.95 | 460.94 | | 3.06 |
| $S_3$ | $I_2$ | 1487.72 | 354.22 | 144 | 2.46 | 1505.14 | 358.37 | 157 | 2.28 | 1496.43 | 356.29 | 150.5 | 2.37 |
| | $I_3$ | 1287.11 | 306.45 | | 1.13 | 1320.07 | 314.30 | | 2.00 | 1303.59 | 310.38 | | 2.06 |

**Table 6. Consumptive use in (m$^3$fed$^{-1}$) as affected by interaction between sowing dates and irrigation treatments during both seasons.**

| Seasons | 1st season | | | | 2nd season | | | | Mean | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Treatments | $S_1$ | $S_2$ | $S_3$ | I-mean | $S_1$ | $S_2$ | $S_3$ | I-mean | $S_1$ | $S_2$ | $S_3$ | I-mean |
| $I_1$ | 2031.13 | 1954.74 | 1931.21 | 1983.61 | 2047.81 | 1970.13 | 1940.68 | 1913.87 | 2039.47 | 1962.44 | 1935.95 | 1979.29 |
| $I_2$ | 1709.39 | 1553.44 | 1487.72 | 1554.52 | 1732.42 | 1580.63 | 1505.14 | 1489.73 | 1720.91 | 1567.04 | 1496.43 | 1594.79 |
| $I_3$ | 1495.42 | 1330.53 | 1287.11 | 1223.69 | 1550.47 | 1390.56 | 1320.07 | 1153.37 | 1522.95 | 1360.55 | 1303.59 | 1395.70 |
| S-mean | 1707.23 | 1579.90 | 1474.68 | | 1742.9 | 1507.77 | 1306.30 | | 1725.07 | 1543.84 | 1390.49 | |

**It should be notified that the seasonal values of CU included the effective rainfall which equal 486.57 and 507.92, 435.56 m3 fed-1 in the two growing seasons, respectively.**

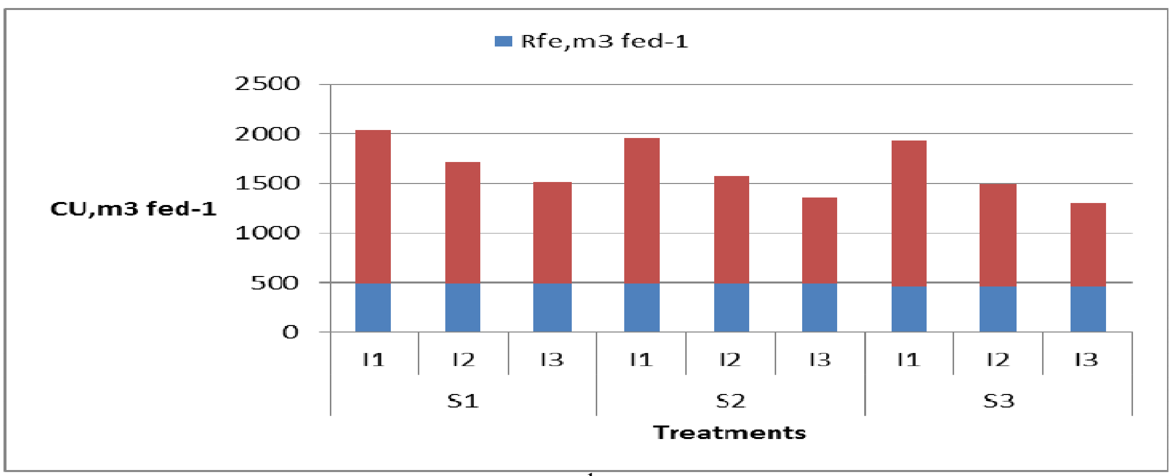


**Fig. 2. Mean seasonal water consumptive use (m3 fed$^{-1}$) for wheat as affected by sowing dates and irrigation treatments in the two growing seasons.**

**4. Crop – water functions**

Water productivity is considered as evaluation parameter, which reflects the yield per unit of consumed water, i.e., WP is a tool for maximizing crop production per each unit of consumed water. Water productivity of wheat was computed for both grain and straw yield in kg m$^{-3}$. Data obtained are presented in Table 7 and illustrated in Fig 3. While the productivity of water applied (PWa) reflects the capability of each unit of applied water in crop production. Both parameters are depending upon the obtained yield as a nominator and water either consumed (Cu) or applied (Wa) as dominator.

Mean values of WP and PWa are presented in Table 8 and illustrated in Figs 3 and 4. Results showed that mean values of WPg were 1.26, 1.4 and 1.48 kg grain m$^{-3}$ in the first season, while, in the second season values were 1.36, 1.54 and 1.59 kg grain m$^{-3}$ resulted from irrigation treatments $I_1$, $I_2$ and $I_3$, respectively. From the presented data, it is clear that values of WP of wheat are pronounced affected by number of irrigations.

Regarding sowing date, values in Tables 7& 8 reveal that $S_1$ treatment achieved the highest value of water productivity with 1.47 kg grain m$^{-3}$ as compared to $S_2$ and $S_3$ (1.41 and 1.27 kg grain m$^{-3}$ ) in the first season, while in the second season $S_2$ treatment achieved the highest values of WP with 1.71kg grain $m^{-3}$ as compared to $S_1$ and $S_3$ (1.4 and 1.4 kg grain $m^{-3}$ ).

In connection with irrigation treatments, $I_3$ treatment resulted in the highest value of WP and PWa. The mean value of WP could be arranged in descending order as1.91, 1.84 and 1.71 kg $m^{-3}$ consumed, while the corresponding value of WPa were 1.84, 1.47 and 1.43 kg $m^{-3}$ applied under irrigation treatments $I_3$, $I_2$ and $I_1$, respectively. These results agreed with *Sun et al (2006), Salemi et al (2011),* chen *et al.*(2014) , Cheikh M'hamed *et al* (2015) Mahamed *et al*. (2011) and Hamed *et al.* (2015) concluded that WUE or so-called water productivity (WP) was decreased with the increase in irrigation water applied.

**Table 7. Means of Water productivity (WP) and productivity of water applied (PWa) for wheat as affected by different sowing dates and water deficit**

| Treatment | | WPg kg $m^{-3}$ consumed | | WPs kg $m^{-3}$ consumed | | PWa g kg $m^{-3}$ applied | | PWas kg $m^{-3}$ applied | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1st seas | 2nd seas | 1st seas | 2nd seas | 1st seas | 2nd seas | 1st seas | 2nd seas |
| | I1 | 1.40 | 1.30 | 2.28 | 1.96 | 1.11 | 1.02 | 1.82 | 1.54 |
| S1 | I2 | 1.48 | 1.43 | 2.14 | 2.03 | 1.16 | 1.12 | 1.66 | 1.59 |
| | I3 | 1.53 | 1.46 | 2.15 | 2.19 | 1.24 | 1.20 | 1.74 | 1.79 |
| | I1 | 1.25 | 1.56 | 1.97 | 2.41 | 1.09 | 1.26 | 1.72 | 1.95 |
| S2 | I2 | 1.45 | 1.75 | 2.17 | 2.41 | 1.17 | 1.40 | 1.76 | 1.93 |
| | I3 | 1.53 | 1.81 | 2.39 | 2.42 | 1.26 | 1.51 | 1.98 | 2.02 |
| | I1 | 1.12 | 1.23 | 1.98 | 2.05 | 1.02 | 1.04 | 1.80 | 1.73 |
| S3 | I2 | 1.31 | 1.45 | 2.17 | 2.22 | 1.07 | 1.16 | 1.78 | 1.78 |
| | I3 | 1.37 | 1.51 | 2.26 | 2.32 | 1.18 | 1.27 | 1.95 | 1.96 |

**PWa g = productivity of water applied for grain, * PWas= productivity of water applied for grain**

**Table 8. Mean water productivity (WP) and productivity of water applied (PWa) for wheat as affected by interaction between sowing date and irrigation treatment in the two seasons.**

| Treatment | | Mean WPg kg $m^{-3}$ | | | | Mean WPs kg $m^{-3}$ | | | | Mean PWag kg $m^{-3}$ | | | | Mean PWas kg $m^{-3}$ | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | I | 1st seas | | 2nd seas | | 1st seas | | 2nd seas | | 1st seas | | 2nd seas | | 1st seas | | 2nd seas | |
| | | S-mean | I-mean | S-mean | I-mean | S-mean | I-mean | S-mean | I-mean | S-mean | I-mean | S-mean | I-mean | S-mean | I-mean | S-mean | I-mean |
| S1 | I1 | 1.47 | 1.26 | 1.40 | 1.36 | 2.19 | 2.08 | 2.06 | 2.14 | 1.17 | 1.07 | 1.11 | 1.11 | 1.74 | 1.78 | 1.64 | 1.74 |
| S2 | I2 | 1.41 | 1.4 | 1.71 | 1.54 | 2.18 | 2.16 | 2.41 | 2.22 | 1.17 | 1.13 | 1.39 | 1.23 | 1.82 | 1.73 | 1.97 | 1.77 |
| S3 | I3 | 1.27 | 1.48 | 1.40 | 1.59 | 2.14 | 2.27 | 2.20 | 2.31 | 1.09 | 2.23 | 1.16 | 1.33 | 1.8 | 1.89 | 1.82 | 1.92 |

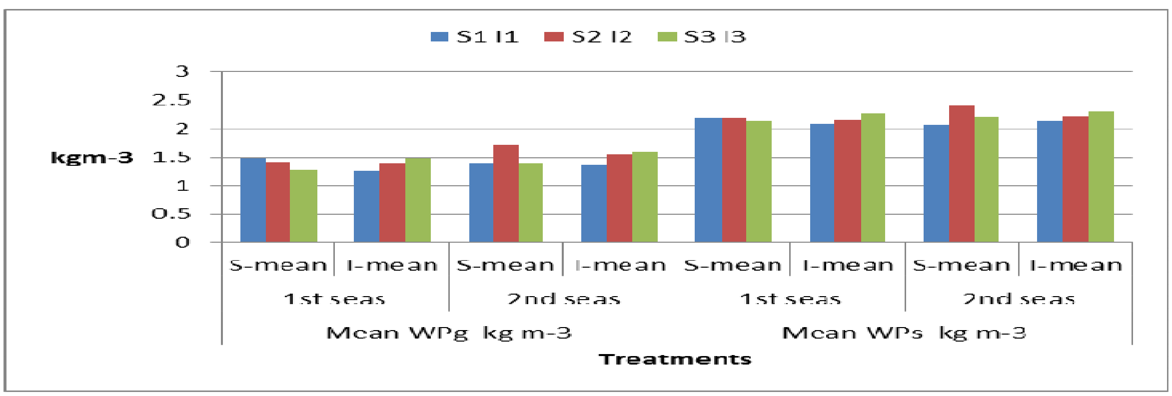


**Fig. 3. Means of water productivity (WP) for wheat as affected by sowing date and irrigation treatments in two growing seasons.**

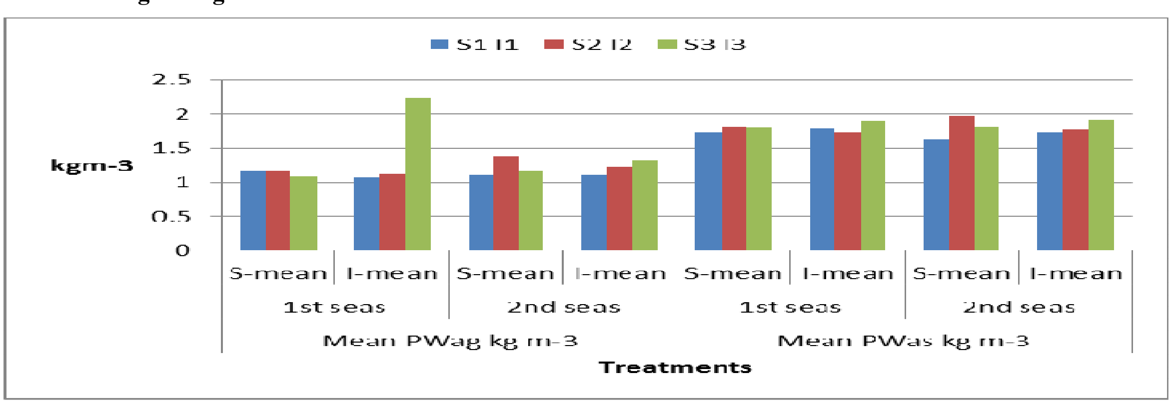


**Fig. 4. Means of productivity of water applied (PWa) for wheat as affected by sowing date and irrigation treatments in two growing seasons.**

**B. Yield and its components:**

The effect of sowing dates on wheat yield and its components was significant in first season (2013/2014).The highest grain and straw yields were obtained from $S_1$ (15th November) with 2553.3& 3832.03 kg $fed^{-1}$. Meanwhile, the third sowing date (15th December) produced the lowest grain and straw yields as 1957.04 &3456.29 kg $fed^{-1}$ (Table 9). On the other hand, the highest grain yield in the second season was obtained from $S_2$ (30th November) with 2783.3& 3979.81 kg $fed^{-1}$, meanwhile the third sowing date (15th December) produced the lowest grain and straw yields with 2187.04 &3462.12 kg $fed^{-1}$. Moreover results of weight of 1000 grain, (g) , HI, (%), Plant height, (cm) and biological yield (kg $m^{-3)}$ took the same trend in the two seasons of study. The obtained results is agreed with that obtained by *Ouda et al.(2005)* and *Akhtar et al. (2006)* whom stated that the highest grain yield was obtained when wheat was sown on the first of December, followed by 15th of November, compared with other sowing dates.

Concerning irrigation treatments, data of the two studied seasons cleared that average yield increased with increasing irrigation number under all sowing dates. These results agreed with *Chen et al (2014)* who reported that average yield increased with increasing number of irrigations from rain-fed up to 4 times. Moreover results of weight of 1000 grain (g), HI (%) , Plant height (cm) and biological yield (kg $m^{-3}$) took the same trend in the two seasons of study. These results agreed with Singh *et al*. (2009) who found that the yield and yield components of wheat plant were decreased with decreasing the irrigation water amount as well as the quality.

**Table 9. Means of effect of irrigation and sowing dates treatments on bio-yield (Kg $fed^{-1}$)yield, grain and straw yield (Kg $fed^{-1}$), harvest index(%) and yield components for wheat**

| Treatment | | Bio. yield Kg $fed^{-1}$ | | straw yield Kg $fed^{-1}$ | | Grain yield Kgfed-1 | | HI, % | | W. of 1000 grain gm | | Plant height, cm | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1st seas | 2nd seas | 1st seas | 2nd seas | 1st seas | 2nd seas | 1st seas | 2nd seas | 1st seas | 2nd seas | 1st seas | 2nd seas |
| | I1 | 7462.7 | 6676.7 | 4628.1 | 4010.3 | 2834.6 | 2666.4 | 38 | 39.9 | 49.7 | 47.8 | 98.7 | 90.3 |
| S1 | I2 | 6186.7 | 6003 | 3651.3 | 3651.3 | 2535.4 | 2476.8 | 41 | 41.3 | 45.8 | 43.9 | 87.5 | 79 |
| | I3 | 5506.7 | 5656.1 | 3216.7 | 3393.2 | 2290 | 2262.9 | 41.6 | 40 | 41.6 | 38.1 | 76.7 | 70.6 |
| Mean | | 6385.4 | 6111.9 | 3832.03 | 3643.2 | 2553.3 | 2468.7 | 40.2 | 40.4 | 45.7 | 43.3 | 87.6 | 80.0 |
| | I1 | 6286.7 | 7816 | 3850.3 | 4751.4 | 2436.4 | 3064.6 | 38.8 | 39.2 | 44.8 | 52.7 | 89.7 | 99.3 |
| S2 | I2 | 5613 | 6576.7 | 3366.2 | 3811.3 | 2246.8 | 2765.4 | 40 | 42.1 | 40.9 | 48.8 | 78.4 | 88.1 |
| | I3 | 5221.4 | 5896.7 | 3188.5 | 3376.7 | 2032.9 | 2520 | 38.9 | 42.7 | 35.1 | 44.6 | 70 | 77.3 |
| Mean | | 5707.0 | 6763.1 | 3468.3 | 3979.8 | 2238.7 | 2783.3 | 39.2 | 41.3 | 40.3 | 48.7 | 79.4 | 88.2 |
| | I1 | 5976.7 | 6366.7 | 3814.2 | 3974.2 | 2162.5 | 2392.5 | 36.2 | 37.6 | 40.7 | 43.7 | 80.4 | 81 |
| S3 | I2 | 5183.7 | 5528.9 | 3233.2 | 3348.5 | 1950.4 | 2180.4 | 37.6 | 39.9 | 35.9 | 38.9 | 70.3 | 70.9 |
| | I3 | 4662 | 5052 | 2903.8 | 3063.8 | 1758.2 | 1988.2 | 37.7 | 39.4 | 30.5 | 33.5 | 60.6 | 61.2 |
| Mean | | 5274.1 | 5649.2 | 3317.1 | 3462.2 | 1957.0 | 2187.0 | 37.2 | 39.0 | 35.7 | 38.7 | 70.4 | 71.0 |
| L.S.D. 0.05 at I | | 100.29 | 98.40 | 91.86 | 102.20 | 96.22 | 96.22 | 1.44 | 1.42 | 0.316 | 0.316 | 1.07 | 1.07 |
| F. Test | | ** | ** | * | * | *** | *** | ns | * | *** | *** | *** | *** |
| L.S.D. 0.05 at S. | | 288.09 | 279.81 | 303.61 | 296.69 | 61.10 | 61.10 | 2.44 | 2.32 | 0.388 | 0.388 | 1.73 | 1.73 |
| F. Test | | *** | *** | *** | *** | *** | *** | * | * | *** | *** | *** | *** |
| I * S | | *** | *** | *** | *** | ns | ns | ns | Ns | *** | *** | ns | ns |

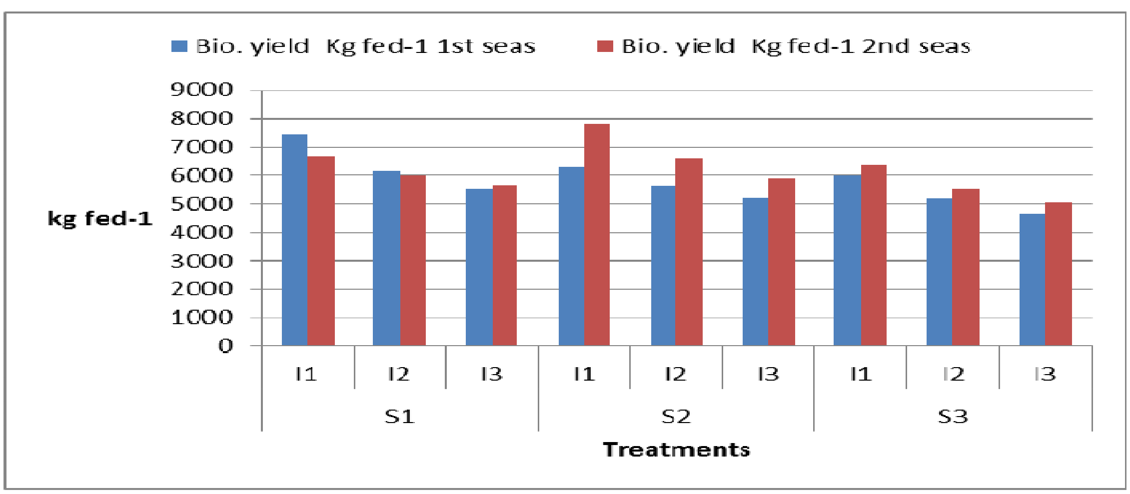


**Fig. 5. Effect of water deficit and sowing date on biological yield of wheat.**

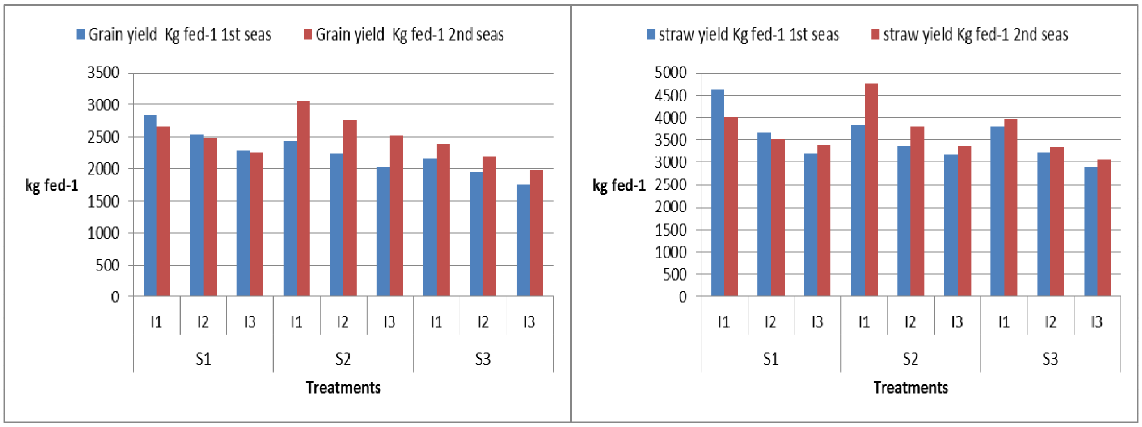


**Fig. 6. Effect of water deficit and sowing date on grain and straw yield of wheat.**

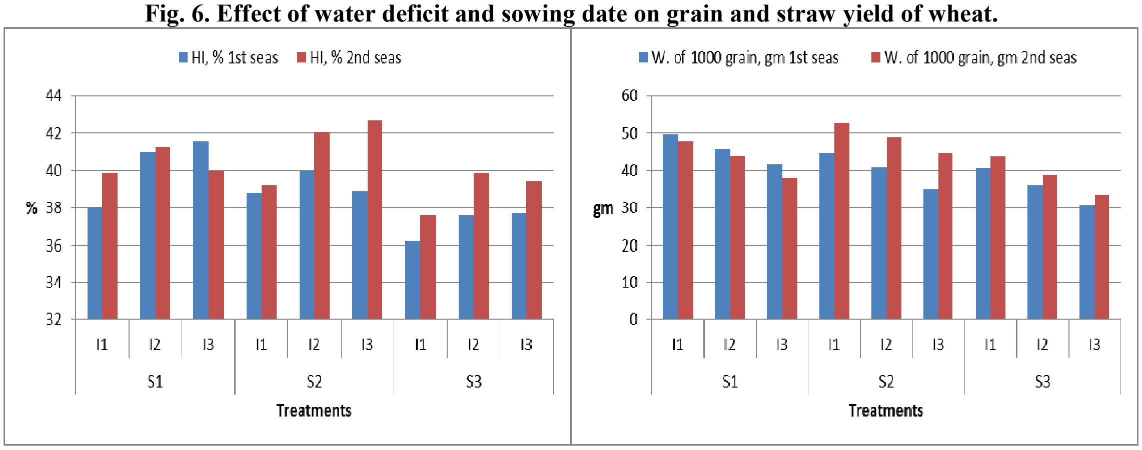


**Fig. 7. Effect of number of irrigations and sowing date on harvest index and weight of 1000 grain of wheat.**

Therefore, it could be summarized the impact of sowing dates and irrigation treatments on grain yield of wheat as, first sowing (15th Nov.) is resulted in the highest yield of 100 % followed by 88% and 77% for second and third sowing date, respectively. While, the main corresponding percentages regarding irrigation treatments are 100, 91 and 82% for I1, I2 and I3, respectively.

## CONCLUSION AND RECOMMENDATIONS

The conjunctive use of rainfall with irrigation in North Nile Delta is an effective way in rationalization of irrigating wheat crop with its contribution is between 27.3 to 46.6% from water applied. The most suitable sowing date for wheat in North Nile Delta is between at 15 – 30$^{th}$ November. In case of enough availability of irrigation water, four irrigation following sowing could produce the highest wheat yield for both grain and straw. On the other hand, water shortage as presented two irrigation after sowing could produce about 82% from maximum yield. Mean crop water productivity is about 1.4 kgm$^{-3}$ consumed. Meaningfully, one kg wheat grain needed 0.714 m3 or 714 litre water consumed. While, the corresponding value for straw is about 0.435 m3 or 435 litre.

## REFERENCES

Akhtar M, M.S Cheema; Moazzam Jamil and Ali L . (2006). Effect of time of sowing on some important characters of wheat, Triticum aestivum genotypes. Journal of Agricultural Research 44: 255-261.

Ali, M.H.; Hoque M.R.; Hassan A.A. and khair A. (2007). Effects of deficit irrigation on yield, water productivity and economic returns of wheat. Agricultural water management, 92 (3): 151-161.

Allen, R. G. (1991). Irrigation Engineering Principles. Utah State Univ.

Bos, M.G. (1980). Irrigation efficiencies at crop production level. ICID. Bulletin 29, 2: 189-260 New Delhi.

Breiman, A. and Graur D. (1995). Wheat Evaluation. Israel J Plant Sci. 43:58-95. Colwell, 1994 J.D. Colwell, Estimating Fertilizer Requirements. A Quantitative Approach, CAB International, UK (1994) p. 259.

Cheikh M'hamed ,H,; Rezig M. and Ben Naceur M.(2015). Water use efficiency of durum wheat (Triticum durum Desf) under deficit irrigation journal of Agricultural Science; 7 (8):238-249

Chen S.; Sun, H.; Shao. L. and Zhang X. (2014). Performance of winter wheat under different irrigation regimes associated with weather conditions in the North China Plain. AJCS 8(4):550-557.

Hamed, H.C.M.; Rezig M. and Naceur. M.B. (2015). Water use efficiency of durum wheat (Triticum durum Desf) under deficit irrigation. Journal of Agricultural Sciences 7: 238-249.

Hansen, V.; Israelsen W. and Stringharm Q.E. (1979). Irrigation Principles and practices,4$^{th}$ (ed.), John Willey and Sons, New York.

Jackson, M. l. (1973). Soil Chemical Analysis. prentice Hall of India private, LTD New Delhi.

James, L. G. (1988). Principles of Farm Irrigation System Design. John Willey and Sons Inc., New York, 543.

Khalil, F. A. F; El-Shaarawy, G.A. and Hasan, H.Y.M. (2007). Irrigation scheduling for some wheat cultivars through pan evaporation norms and its effect on growth, yield and water use efficiency. Fayoum J. of Agric. Res& dev., 21(1):1-15.

Klute, A.C. (1986). Water retention: laboratory Methods. In: A. koute (ed.), Methods of Soil Analysis, part 1- 2nd(ed.) Agronomy Monogr.9, ASA, Madison, W1 U.S.A, pp. 635 – 660.

Mahamed, M.B.; Sarobol, E.D. ; Hordofa, T.; Kaewrueng S. and Verawudh. J. (2011). Effects of soil moisture depletion at different growth stages on yield and water use efficiency of bread wheat grown in semi-arid conditions in Ethiopia. Kasetsart Journal Natural Science 45: 201-208.

Michael, A. M. (1978). Irrigation – Theory and Practices. Vikas Publishing House, New Delhi

Moussa, A.M. and Abdel-Maksoud. H. H. (2004). Effect of soil moisture regime on yield and its components and water use efficiency for some wheat cultivars. Annals Agric. Sci., Ain Shams Univ., 49(2), 515-530.

Novica, V. (1979). Irrigation of Agriculture Crops. Fac. Agric. Press, Novi Sad Yugoslavia.

Ouda S.A.; El-Marsafawy, S.M.; El-Kholy M.A. and Gaballah M.S. (2005). Simulating the effect of water stress and different sowing dates on wheat production in South Delta. Journal of Applied Sciences Research 1(3): 268-276,

Rezgui, M. (2014). Irrigation de complément et efficience de l'utilisation de l'eau de quelques variétés de blé dur cultivées en Tunisie. Journée Nationale sur la valorisation des Résultats de la Recherche dans le Domaine des Grandes Cultures. Tunis, le 17 avril 2014.

Rezgui, M.; Zairii, A. ; Bizid E. and Ben Mechlia N. (2005). Consommation et efficacité d'utilisation de l'eau chez le blé dur (Triticum durum Desf.) cultivé en conditions pluviales et irriguées en Tunisie. Cahiers Agricultures, 14(4): 391-397.

Salemi, H.; Soom, M. A. M.; Lee, T. S. ; Mousavi, S. F; Ganji, A. and Kamil Yusoff, M. (2011). Application of AquaCrop model in deficit irrigation management of winter wheat in arid region. African Journal of Agricultural Research 610:2204–2215.

Singh R.B.; Chauhna, C.P.S. and Minhas, P.S. (2009). Water production function of wheat irrigation with saline and alkali water using double line source sprinkler system. Agric. Water Manage., 96: 736-744.

Sun, H.Y.; Liu, C.M. ; Zhang, X.Y. ; Shen, Y.Q. and Zhang, Y.J.(2006). Effects of irrigation on water balance, yield and WUE of winter wheat in the North China Plain. Agric. Water Manage., 48: 151-167.

Xue, Q.; Zhu, Z.; Musick, J. T.; Stewart, B. A. and Dusek, D. A. (2006). Physiological mechanisms contributing to the increased water-use efficiency in winter wheat under deficit irrigation. J. Plant Physiol., 163, 154-164.

Zhang, X.; Chen, S.; Liu, M.; Pei, D. and Sun, H. (2005). Improved water use efficiency associated with cultivars and agronomic management in the north China plain. Agron. J., 97, 783-790.

## اثر مواعيد الزراعه المختلفه والعجز المائي علي انتاجية محصول القمح من وحدة المياه

**احمد عبد القادر طه[١]، محمد عبد الفتاح ابراهيم[٢] ، احمد علي ابو العطا موسي[١] و محمد نصر الكومي [٢]**

**[١] كلية الزراعه – جامعة المنصوره**

**[٢]معهد بحوث الاراضى والمياه والبيئة - مركز البحوث الزراعية – الجيزة – مصر**

اجريت تجربة حقلية بمزرعة محطة البحوث الزراعية بسخا بمحافظة كفر الشيخ خلال شتوي الموسمين الزراعيين٢٠١٣/٢٠١٤ و ٢٠١٤/٢٠١٥ بهدف دراسة تاثير مواعيد الزراعه والعجز المائي علي انتاجية محصول القمح. المعاملات الرئيسيه كانت مواعيد الزراعه معاملة س١ (١٥ نوفمبر ) , س٢ (في ٣٠ نوفمبر) , وس٣ ( ١٥ ديسمبر ) بينما المعاملات تحت الرئيسيه كانت معاملات الري: معاملة أ (اضافة اربع ريات بخلاف رية الزراعه) ، معاملة ب (اضافة ثلاث ريات بخلاف رية الزراعة)، معاملة ج (اضافة ريتين بخلاف رية الزراعة). والصنف المنزرع مصر٢ والتصميم الاحصائى المستخدم هو قطع منشقه مره واحده فى ثلاث مكررات.اهم النتائج المتحصل عليها: سجلت أعلى قيمة لكلا من كمية المياة المضافة والاستهلاك المائى تحت ميعاد الزراعه الاول وتحت معاملة الري الاولي (اربع ريات) فى موسمى الزراعة وكانت متوسط القيم لموسمى الدراسة هى ٦١٣.٦مم و ٤٨٥.٦مم لكلا من كمية المياة المضافة والاستهلاك المائى على التوالى. بينما اقل القيم المسجله كانت تحت معاملة ميعاد الزراعه الثالث ومعاملة الري الثالثه ( ريتين) وكانت متوسط القيم لموسمى الدراسة هى ٣٦٣.٣مم و ٣١٠.٤مم لكلا من كمية المياة المضافة والاستهلاك المائى على التوالى. اعلي نسبة مساهمة للأمطار من كمية المياة المضافة كانت ٤٦.٦٪ و٣٨.٤٪ تحت معاملة ميعاد الزراعه الثالث ومعاملة الري الثالثه ( ريتين) وبصفه عامه تحت ميعاد الزراعه الثالث خلال موسمي الدراسه الاول بينما في الموسم الثاني كانت اعلي مساهمه من الامطار تحت معاملة الريه الثالثه وميعاد الزراعه الثاني وكانت القيم ٤٣.٤٪ و ٣٥.٧٪ علي التوالي بينما اقل نسبة مساهمة للأمطار فى كمية المياة المضافة كانت ٢٧.٨٪ و٣٢.٤٪ تحت معاملة ميعاد الزراعه الاول ومعاملة الري الاولي ( اربع ريات) وبصفه عامه تحت موعد الزراعه الاول خلال موسمي الدراسه .أعلى متوسط لقيم انتاجية المياة بالنسبه للحبوب والقش (WPg , WPs) سجلت تحت المعاملة موعد الزراعه الاول عموما ومعاملة الري الثالثه عموما فى موسم ٢٠١٣/٢٠١٤ وكانت القيم ١.٤٧و ١.٤٨و ٢.٢٧ و ٢.١٩ كجم م$^{-٣}$ ماء مستهلك بينما في الموسم الثاني ٢٠١٤/٢٠١٥ كانت اعلي القيم المسجله تحت المعامله ميعاد الزراعه الثاني ومعاملة الري الثالثه (ريتين) وكانت القيم ١.٧و ١.٥٩و ٢.٣١و ٢.٤١ كجم م$^{-٣}$ ماء مستهلك علي التوالي.أعلى متوسط لقيم انتاجية المياة المضافة بالنسبه للحبوب والقش (PWag, PWas) سجلت تحت المعاملة موعد الزراعه الثاني عموما ومعاملة الري الثالثه عموما (ريتين) وكانت القيم ١.١٧و ٢.٢٣و ١.٣٩و ١.٣٣و ١.٨٢و ١.٨٩و ١.٩٧و ١.٩٢ كجم م$^{-٣}$ ماء مضاف علي التوالي. كان هناك تاثير معنوي علي معظم صفات المحصول نتيجة لتأثير معاملات الرى ومواعيد الزراعه فى الموسمين فى الصفات التالية: المحصول الكلي- محصول الحبوب - محصول القش - معامل المحصول - طول النبات ووزن ١٠٠٠ حبه حيث وجد أن أعلى القيم نتجت من معاملة الرى الاولي (اربع ريات بعد رية الزراعه) في الموسمين بينما اعلي القيم كانت تحت ميعاد الزراعه الاول في الموسم الاول وتحت ميعاد الزراعه الثاني في الموسم الثاني. وعليه:- توصى الدراسة بامكانية الاستفادة من مياة الأمطار فى انتاجية محصول القمح من خلال تحديد الموعد الافضل للزراعه. يمكن زراعة القمح بمنطقة شمال الدلتا خلال الفتره من منتصف نوفمبر وحتي اول ديسمبر ولايفضل زراعة القمح في منتصف شهر ديسمبر. العائد المحصولي لوحدة المياه المستهلكه في حدود ١.٥ كجم اي ان كجم قمح يلزمه حوالي ٠.٧م٣ ماء , كجم تبن يلزمه حوالي ٠.٥م٣ ماء.