IRRIGATION WATER MANAGEMENT OF WHEAT CROP UNDER SOWING DATES AT FAYOUM

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ABSTRACT

A field experiment was conducted at Kom Osheem Agric., Res., Station, Fayoum, Egypt during 2003/2004 and 2004/2005 seasons to study the effect of three sowing dates, i.e. D_1: 22 Nov., D_2: 2 Dec., and D_3:12 Dec. and irrigation water managements, i.e. irrigation at I_1:30%, I_2:55% and I_3 : 80% available soil moisture depletion (ASMD) on yield, yield components and some water relations of wheat crop (Giza 168 cv.). A split-plot design with four replications was used in both seasons. The main obtained results were as follows:

1. Planting wheat on 22 Nov., and irrigation at 30% ASMD gave the highest averages of plant height, spike number/m^2, grain weight/ m□,1000 – grain weight, grain yield/fed. (1566.0 and 1656.0 kg), and straw yield (3625.9 and 3824.4 kg/fed.) in the two successive seasons. The lowest averages of yield and its components were obtained from sowing on 12 Dec. and irrigation at 80% ASMD in both seasons.
2. Delaying sowing date from 22 Nov. to 12 Dec., significantly decreased all yield components, grain yield/fed by 12.7% and 12.4% and straw yield/fed by 24.7% and 25.6% in 2003/2004 and 2004/2005 seasons, respectively. However, increasing the ASMD from 30% to 80% significantly decreased yield components, grain yield/fed by 29.7% and 24.5%and straw yield/fed by 11.9% and 13.4% in the two successive seasons.
3. Seasonal consumptive use (ETc), as a function of the different treatments averaged 40.40 and 39.70 cm in 2003/2004 and 2004/2005 seasons, respectively. Delaying sowing date from 22 Nov. to 12 Dec., and increasing ASMD from 30% to 80% decreased seasonal Etc from 46.18 and 45.43 cm to 35.35 and 34.85 cm in the two successive seasons.
4. Daily ETc rates were low during Nov. and Dec., then increased during Jan. and Feb., to reach its maximum values during March and declined again at April till harvesting. The values of daily ETc decreased with delaying sowing date than 22 Nov. and increasing ASMD than 30% in the two growing seasons months. The crop coefficient (Kc) values were 0.51, 0.59, 0.67, 0.80, 0.95, 0.69 and 0.49 (averages of the two seasons) for, Nov., Dec., Jan., Feb., Mar., Apr. and May, respectively.
5. The highest water use efficiency values were 0.871 and 0.936 kg grains/m^3 water consumed were obtained from D_3I_2 treatment in 2003/2004 season and D_2I_2 treatment in 2004/2005 season, respectively.

Key words: Wheat yield, yield components, sowing dates, irrigation regimes, water relations.

INTRODUCTION

Wheat is the major cereal crop source of calories and protein in Egypt, and its production shortage is the dominant factor in the food problem.Therefore, applying optimum agricultural treatments for wheat crop, i.e. tillage practices, sowing date, fertilization, weed control with best irrigation water management became a very important concern for in Pakistan, increasing wheat production per unit area cultivated. **Nazir *et al*. (1980)** concluded that number of fertile tillers/unit area, grains/spike and grain yield/ha progressively decreased with delaying sowing from 10 Dec. to 9 Jan. yields were 4.98 and 3.65 t/ha for 10 Dec. and 9 Jan., respectively, whereas the 1000-grain weight was little affected.

Sufian *et al*. (1983) in Bangladesh, showed that grain yields were 2.71, 4.0 and 3.09 t/ha for 31 Oct., 22 Nov. and 22 Dec., sowing, respectively. **Hegab *et al*., (1984)** noticed that the earlier sowing gave the higher yields and yield components. **Tomar and Verma (1985)** in India, indicated that averages of grain yields were 4.41, 4.93 .3.91 and 2.83 t/ha for the 4 sowing dates (from 23 Oct., to 6 Jan). Number of grains/plant, 1000-grain weight and grain yield (5.31 t/ha) were highest from sowing on Nov. 12. **Ibrahim *et al*. (1986)** pointed out that grain yields were 2.69, 4.36, 4.57 and 3.84 t/ha for sowing on 21 Oct., 10 Nov., 30 Nov. and 21 Dec., respectively. **El-Morshidy *et al.* (1998)** found that early sowing in the second half of Nov., with optimum irrigation during all growth stages increased grain yield and its components. **Gupta *et al*. (2004)** in Kashmir, revealed that sowing on 6 Nov., gave the higher grain yield (26.6 quintal/ha), biomass (101.9 q/ha), spike number/m□ (307.4), grain no./spike (19.6) and water use efficiency (9.35 kg/mm/ha), than late sowing. **Rajput and Pandey (2004)** in India, found that grain yield, ear length, number of grains/ear, 1000-grain weight, WUE, leaf area index, crop growth rate were decreased with delaying sowing date from 3 to 23 Jan., and were highest with 55% soil moisture than 40% or 70%.

Regarding the irrigation regimes effect **Doorenbos *et al*. (1979)** indicated that available soil moisture depletion (ASMD) less than 50% had a little effect on water uptake by wheat plants, whereas at 70 ASMD moderate stress occurred and severe stress when ASMD exceeded 80%. Water requirements for high yield ranged between 45 and 65.0 cm, and the crop coefficient (Kc) values were 0.3-0.4, 0.7-0.8, 1.05-1.20, 0.65-0.70 and 0.2-0.25 for initial, development, mid-season, late season and harvest stages, respectively. **Meyer and Green (1980)** showed that expansive growth of wheat was reduced when soil moisture was below 33% ASMD. **El-Sayed (1982)** revealed that seasonal ETc as well as grain and straw yields were depressed by exposing wheat plants to high moisture stress. **Metwally *et al.* (1984)** found that irrigation at 25% ASMD gave the highest grain and straw yields. They added that, ETc values were 47.65, 41.71 and 36.3 cm for irrigation at 25, 50 and 75% ASMD, respectively. **Abdel-Mottaleb and Metwally (1992)** concluded that grain and straw yields were increased with increasing soil moisture .Irrigation at 2 bars gave the highest yield, wheres the lowest one was obtained from irrigation at 8 bars. The ETc was decreased by increasing soil moisture stress. Irrigation at 8 bars gave the highest water use efficiency (WUE). **Yousef and Eid (1994)** at Fayoum reported that the highest values of yield and yield components were obtained from irrigation at 30% ASMD. Increasing ASMD from 50% to 70% significantly decreased yield component, grain yield and straw yield. The ETc increased as the ASMD decreased and the high WUE was resulted from irrigation at 30% ASMD. **Yousef and Hanna (1998)** found that spike number/m^2□, grain number/spike,1000-grain weight and grain and straw yields/fed were significantly decreased by increasing ASMD form 35% to 70%. They added that seasonal ETc were 42.77 and 37.83

cm for irrigation at 35 and 70 ASMD, respectively. However, the Kc values were 0.4, 0.68, 0.79, 1.02, 1.00, 0.61 and 0.39 during Nov., Dec., Jan., Feb., Mar., Apr. and May months, respectively. The highest WUE was resulted from irrigation at 35% ASMD. **Yousef and Eid (1999)** revealed that irrigation at 35% ASMD gave the highest spike number/m^2, 1000-grain weight, grain and spike yields/fed, seasonal Etc (43.7 cm) and WUE (1.065 kg grains/m^3 water consumed), whereas irrigation at 80% gave the lowest mentioned measurements. **Hassain *et al.* (2003)** indicated that irrigating wheat at 4 weeks after emergence gave the highest number of spikes/m^3 (238), however, irrigation at 2 weeks after emergence gave the highest grain yield (4103 kg/ha) and biological yield (10207 kg/ha). **Yousef and Ashry (2006)** found that the highest yield and yield components were resulted from irrigation at 35% ASMD and increasing ASMD to 55 or 75% caused significant reduction in yield components, grain and straw yields. Seasonal ETc values were; 43.13, 40.12 and 39.05 cm for irrigation at 35.55 and 75% ASMD, respectively. The peak of water consumption occurred during March and April and the Kc values were; 0.53, 0.74, 0.87, 0.91, 0.99, 0.60 and 0.41 for Nov., Dec., Jan., Feb., Mar., Apr. and May months, respectively.

MATERIALS AND METHODS

The present investigation was conducted at Fayoum Agric., Res., Station (Kom Osheem) during 2003/2004 and 2004/2005 seasons to study the effect of irrigation water management for wheat crop under different sowing dates on yield, yield components and some crop water relations. Three sowing dates, i.e. D_1: November 22nd, D_2: December 2 and D_3: December 12 were combined with three irrigation regime treatments, i.e. irrigation at I_1: 30%, I_2:55% and I_3: 80% available soil moisture depletion (ASMD), in a split-plot design with four replications. Each plot was isolated from the others by allays 1.5 m between to avoid the lateral movement of water. The soil physical and chemical properties of the experimental plots, were determined according to **Klute (1986) and Page *et al*. (1982)** and are presented in Table (1). The averages of climatic factor for Fayoum Governorate during the wheat crop growing seasons are recorded in Table (2). Dates of irrigation and irrigation count for the different treatments tested in both seasons are listed in Table (3). The sub-plot, area was 21.0 m^2 (3.0 x 7.0 m). Calcium super phosphate (15.5% P2O5) was added at the rate of 150 kg/fed during the field preparation. The preceding crop was grain sorghum in both seasons.

Nitrogen fertilization, as ammonium nitrate 33.0% N at the rate of 75kg N/Fed was applied in three equal doses (at planting, at the 1st and 2nd irrigations). Irrigation regime treatments started from the 2nd irrigation. Wheat grains of Giza 168 cv., at the rate of 70 kg/fed were broadcasted for each sowing date.

The soil moisture values were gravimetrically determined on oven dry basis, as the technique of Water Requirement and Field Irrigation Dept., A.R.C., Egypt for soil layers, each of 15.0 cm from soil surface and down to 60.0 cm depth, and the soil moisture constants, estimated for the experimental field are shown in Table (4).

Table (1). Physical and chemical analysis of the experimental plots at, Kom Osheem.

A. Physical analysis					
Sand%	Silt%	Clay%	Texture clesses	Organic matter%	$CaCo_3$ %
51.5	23.2	25.3	Sandy clay loom	0.91	9.92

B. Chemical analysis														
Ec dS/m	pH 1:2.5 extract	Soluble Cations meg/L				Soluble anions meg/L				CEC meg/100gm soil	Exchangeable Cations meg/100gm soil			
		Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Cl	Hco_3	Co_3	So_4		Ca^{++}	Mg^{++}	Na^{+}	K^{+}
7.83	8.19	17.22	10.21	46.92	1.82	38.15	2.94	-	35.08	20.12	9.85	6.92	2.16	0.78

Table (2). Monthly averages of climatic factors for Fayoum Governorate during 2003/2004 and 2004/2005 seasons.

Monthly	Season	Temperature C° Max.	Temperature C° Min.	Temperature C° Mean	Relative humidity %	Wind speed m/sec.	Solar** radiation	Class A* pan evaporation (mm/day)
November	2003	27.7	16.6	21.6	62	1.7	5.38	3.7
	2004	27.7	13.7	20.7	55	2.2	5.65	3.2
December	2003	22.4	9.4	15.4	58	2.6	4.77	2.5
	2004	21.6	8.1	14.8	59	2.4	4.58	1.8
January	2004	21.2	8.8	16.0	58	2.4	5.27	1.8
	2005	21.1	7.6	14.2	56	2.1	5.17	2.0
February	2004	23.8	8.6	16.2	60	2.0	7.08	2.1
	2005	21.0	6.9	13.9	55	2.2	6.42	2.6
March	2004	25.2	10.1	17.06	56	2.3	8.44	4.0
	2005	25.2	9.4	17.3	53	2.2	8.13	4.0
April	2004	29.7	13.1	21.4	51	2.0	10.49	5.1
	2005	30.4	13.0	21.7	51	3.0	10.14	5.3

* After Fayoum Meteoralogical station (Etsa destrict)
** Calculated by Sammani (2002) equation.

At harvest which done on May 4 and 1 in the first and seasond season, respectively, the following data were collected for each sub-plot.

I. Yield and yield components :

1- Plant height (cm^2) .
2- Spike number /m^2 .
3- Grain weight/m^2
4-1000 – grain weight (g).
5- Grain yield/fed: estimated from the yield of the whole sub-plot , in kg/fed.
6- Straw yield/fed : estimated from the yield of the whole sub-plot in kg/fed.

All the collected data were subjected to the statistical analysis according to the procedures outlined by **Snedecor and Cochran (1980)** and the means were compared by L.S.D. test at 5.0% level.

Table 3

II. Crop water relations:

1. Seasonal consumptive use (ETc).

For determining the crop water consumptive use (ETc), soil samples were taken from each sub-plot, just before and after 48 hours from each irrigation, as well as at harvesting time and the ETc between each two successive irrigations was calculated according to the following equation **(Israelsen and Hansen, 1962)**.

CU or (ETc) = [(Φ2 – Φ1) / 100]. Bd. D

Where : ETc = Crop evapotranspiration in cm .

θ2 = Soil moisture % 48 hours after irrigation.

θ1 = Soil moisture % just before irrigation.

Bd = Soil Bulk density (g/cm^3) .

D = Soil depth (cm).

2. Daily ETc rate (mm/day)/month.

Calculated from the consumptive use value of each month , divided by the number of days/month.

3. Reference evapotranspiration (ETo) in mm/day.

Estimated using the monthly averages of Fayoum climatic data (Table, 2) and the FAO Penman-Monteith equation (**Allen *et al.* 1998**)

4. Crop coefficient (Kc).

The values of Kc were calculated as follows :

$$\frac{\text{Actual crop consumptive use rate/month (mm/day)}}{\text{Reference evapotranspiration rate/month (mm/day)}}$$

5. Water use efficiency (WUE)

The WUE, as kg grains/m^3 water consumed was calculated for different treatments as the method described by **Vites (1965)**.

$$WUE = \frac{\text{Grain yield (kg/fed.)}}{\text{Seasonal ETc (m}^3\text{/fed.)}}$$

Table (4). The soil moisture constants of the experimental field (average of the two seasons)

Soil depth (cm)	Field Capacity (%)	Wilting point (%)	Available moisture (%)	Bulk density (g/cm^3)
0-15	35.42	17.42	18.00	1.49
15-30	32.42	16.99	15.43	1.51
30-45	30.42	15.02	15.40	1.57
45-60	28.89	14.69	14.20	1.52

RESULTS AND DISCUSSION

I-Yield and yield components:

1. Yield components:

The results presented in Table (5) reveal that delaying sowing date from 22 Nov. to 2 Dec. or 12 Dec., significantly decreased all yield components measured in both seasons. Sowing wheat on 22 Nov., gave the highest averages of plant height, spike number/m^2, grain weight/m^2 and 1000-grain weight in both seasons. However, delaying sowing from 22 Nov. to 2 Dec., significantly decreased plant height, spike number/m^2, grain weight/m^2 and 1000-grain weight in 2003/2004 season by 8.65%, 9.32%, 6.50 and 7.96%, respectively, and spike number/m^2, grain weight/m^2 and 1000-grain weight in 2004/2005 season by 11.42%, 5.56% and 8.47%, respectively, while plant height did not significantly differed. Mate over, delay in sowing from 22 Nov. to 12 Dec., significantly reduced plant height, spike number/m□, grain weight/m□ and 1000-grain weight in 2003/2004 season by 1123.5%, 12.56%, 12.7% and 14.12%, respectively, and in 2004/2005 season by 11.7%, 29.85%, 14.45% and 18.33%, respectively. These results may be due to the effect of low temperature during the early vegetative growth in countered the late sowing plants, which reduced tillering, stem elongation and dry matter accumulation in plant organs. The obtained results are in the same line with those reported by **Nazir *et al.* (1980), Tomar and Verna (1985), El-Morshidy *et al.* (1998), Gupta *et al.* (2004) and Rajput and Pandey (2004).**

Regarding, the effect of irrigation regime treatments, data recorded in Table (5) show that wheat yield components were significantly affected by irrigation regimes in both seasons. Irrigation wheat plants at 30% ASMD gave the highest averages of yield components, whereas irrigation at 80% ASMD gave the lowest ones in both seasons. Increasing available soil moisture depletion from 30% to 55% ASMD, in 2003/2004 season significantly decreased plant height, spike number/m□, grain weight/m□ and 1000-grain weight by 3.83%, 5.6%, 4.24% and 9.44%, respectively. However, in 2004/2005 season, spike number/m□, grain weight/m□ and 1000-grain weight were significantly decreased by 7.55%, 4.98% and 3.87%, respectively, while plant height did not significantly differ. More increase in the soil moisture depletion from 30% to 80% resulted in a remarkable reduction in plant height, spike number/m□, grain weight/m□ and 1000-grain weight in 2003/2004 season equal to 8.7%, 27.8%, 29.6% and 14.32%, respectively and in 2004/2005 season equal to 20.9%, 21.0%, 22.3% and 17.61%, respectively. It is obvious that increasing ASMD caused a significant decrease in wheat yield components. These results may be referred to the effect of moisture stress on reducing photosynthesis, cell division, stem elongation, leaf area, leaf duration, tillering and dry matter accumulation in plant organs. The obtained results are in consistent with those found by **Meyer and Green (1980), Yousef and Eid (1994), Yousef and Hanna (1998), Yousef and Eid (1999), Hussain *et al.* (2003) and Yousef and Ashry (2006)**

The data listed in Table (5) indicate that all yield components were significantly affected by the interaction between sowing dates and irrigation regimes in both seasons. The highest averages of plant height, spike number/m□, grain weight/m□ and 1000-grain weight were detected from sowing on 22 Nov., and irrigation at 30% ASMD in both seasons. However, the lowest averages of the mentioned yield components were resulted from late sowing (12 Dec.) and irrigation at 80% ASMD (D3I3) in both seasons. It could be concluded that early sowing and irrigation at low soil moisture depletion resulted in higher yield components under Fayoum conditions.

2. Grain and Straw yields

The obtained results in Table (5) reveal that the averages of grain and straw yields were significantly differed due to sowing dates in both seasons. Sowing wheat on 22 Nov. gave the highest grain yields, i.e 1416.5 and 1484.6 kg/fed and highest straw yields, i.e. 3316.1 and 3477.3 kg/fed in 2003/2004 and 2004/2005 seasons, respectively Delaying sowing date from 22 Nov. to 2 Dec. significantly decreased grain yields by 6.49% and 3.34% and straw yields by 11.49% and 11.04% in the two successive seasons, respectively. However, the grain and straw yields of 22 Nov. sowing, surpassed those of 22 Dec. sowing in

2003/2004 season by 12.66% and 24.67%, respectively, and in 2004/2005 season by 12.43% and 25.65%, respectively. It is evident that delaying sowing date than 22 Nov. significant by decreased grain and straw yields. These results may be attributed to the effect of delaying sowing date on yield components and number of tillers/plant as well as decreasing the vegetative growth period duration. These results are in harmony with those reported by **Nazir *et al.* (1980)**, **Sufian *et al.* (1983), Hegab *et al.* (1984), Tamar and Verna (1985), Ibrahim *et al.* (1986), El-Morshidy (1998), Gupta *et al.* (2004) and Rajput and Pandey (2004).**

Concerning the effect of irrigation regime treatments, data recorded in Table (5) indicate that irrigation regimes have significant effects on grain and straw yields in both seasons. Irrigation at 30% ASMD gave the highest averages of grain and straw yield in 2003/2004 season, i.e. 1495.1 and 3099.2 kg/fed, respectively and in 2004/2005 season, i.e. 1559.9 and 3270.4 kg/fed., respectively. Grain and straw yields detected from irrigation at 30% ASMD over yielded those, obtained from irrigation at 55% ASMD in 2003/2004 season by 4.25% and 5.82%, respectively, and in 2004/2005 season by 4.99% and 6.59%, respectively. However, subjecting wheat plants to more water stress by irrigation at 80% ASMD significantly decreased grain and straw yields in 2003/2004 season by 29.67% and 11.87%, respectively, and in 2004/2005 season by 24.5% and 13.44%, respectively, comparing to irrigation at 30% ASMD. It could be revealed that subjecting wheat plants to water stress by irrigation at high ASMD (long intervals) significantly decreased grain and straw yields/fed. Such findings may be referred to the effect of water stress on reducing growth attributes, plant height, spike number/m☐, grain weight/m☐ and 1000-grain weight. These results are in agreement with those found by **Doorenbos *et al.* (1979), El-Sayed (1982), Metwallly *et al.* (1984), Abdel-Mottaleb and Metwally (1992), Yousef and Hanna (1998), Hussain *et al*. (2003) and Yousef and Ashry (2006).**

Results in Table (5) show that wheat grain and straw yields were significantly affected by the interaction between sowing dates and irrigation regime treatments in both seasons. The highest grain yield, i.e. 1566.0 and 1656.1 kg/fed and highest straw yield, i.e. 3625.9 and 3824.4 kg/fed in 2003/2004 and 2004/2005, respectively, were detected from sowing wheat on 22 Nov. and irrigation at 30% ASMD (D_1I_1 treatment) However, late sowing on 12 Dec. and irrigation at 80% ASMD (D_3I_3 treatment) gave the lowest grain yield (929.0 and 1099.6 kg/fed.) and lowest straw yield (2440.3 and 2509.2 kg/fed.) in 2003/2004 and 2004/2005 seasons, respectively. It could be concluded that sowing wheat on optimum date and irrigation at low ASMD significantly increased grain and straw yields.

II. Crop water relations:

1. Seasonal consumptive use (ETc).

The results presented in Table (6) indicate that seasonal consumptive use or evapotraspiration (ETc) of wheat crop, as a function of sowing dates and irrigation regime treatments were; 40.40 cm and 39.70 cm in 2003/2004 and 2004/2005 seasons, respectively. The difference may be due to the variation in climatic factors of the two seasons (Table, 2). Sowing wheat on 22 Nov. gave the highest values of wheat ET, i.e. 43.48 and 42.82 cm in the two successive seasons. Delaying sowing date from 22 Nov. to 2 or 12 Dec. decreased seasonal ETc in 2003/2004 season by 5.06% and 13.87%, respectively, and in 2004/2005 season by 7.94% and 13.94%, respectively. It is obvious, that

Table 5

delaying sowing date of wheat resulted in decreasing seasonal consumptive use. These results may be referred to that delaying sowing dates may decrease the crop growing period, especially vegetative growth period and vegetative growth attributes, as well as number of applied irrigations.

Regarding the effect of irrigation regime treatments, data recorded in Table (6) show that irrigating wheat plants at 30% ASMD (short intervals) produced the highest values of ETc, i.e. 42.75 and 42.33 cm in 2003/2004 and 2004/2005 seasons, respectively. The lowest ETc values, i.e. 38.01 and 37.37 cm were resulted from irrigation at 80% ASMD in the two successive seasons. However, irrigation at 55% ASMD decreased ETc by 5.38% and 6.94% in 2003/2004 and 2004/2005 seasons, respectively. It could be concluded that increasing the available soil moisture in the root zone of wheat plants caused increase in ETc/season. These results may be due to the high transpiration rates from plants and high evaporative demands from soil under high available moisture, whereas under water stress, the transpiration from plants may decreased as a result of poor vegetative growth, also the evaporation decreased from dry soil surface. These results are in accordance with those reported by **Doorenbos *et al.* (1979), El-Sayed (1982) Metwally *et al.* (1984), Abdel-Mottale and Metwally (1992), Yousef and Hanna (1998) and Yousef and Ashry (2006) .**

The data listed in Table (6) indicate that sowing wheat on 22 Nov. and irrigation at 30% ASMD gave the highest values of ETc, i.e. 46.18 and 45.43 cm in 2003/2004 ad 2004/2005 seasons, respectively. However, the lowest ETc values, i.e. 37.45 and 34.85 cm in the two successive seasons were detected from interaction between sowing on 12 Dec. and irrigation at 80% ASMD.

Table (6). Effect of sowing date, irrigation regime treatments and their interaction on seasonal consumptive use (ETc) of wheat in 2003/2004 and 2004/2005 seasons.

Sowing dates (D)	2003/2004				2004/2005			
	Irrigation regimes (ASMD)				Irrigation regimes (ASMD)			
	(I_1) 30%	(I_2) 55%	(I_3) 80%	Mean	(I_1) 30%	(I_2) 55%	(I_3) 80%	Mean
(D_1) 22/11	46.18	43.43	40.84	43.48	45.43	42.80	40.24	42.82
(D_2) 2/12	42.19	40.80	37.85	40.28	42.19	39.05	37.03	39.42
(D_3) 12/12	39.87	37.12	35.35	37.45	39.38	36.32	34.85	36.85
Mean	42.75	40.45	38.01	40.40	42.33	39.39	37.37	39.70

2- Daily ETc (mm/day).

The results presented in Table (7) show that the daily ETc rates as influenced by different treatments tested in both seasons were started with low values during Nov. and decreased more during Dec., increased again during Jan. and Feb. to reach their maximum values on March. Thereafter, it redecreased again during April and May (plant harvesting). These results are referred to that at the initial growth stage, most of the water loss is due to evaporation from the bare soil (germination and seedling stages) and the reduction in ETc rate during Dec. was due to the decrease in evaporative demands (temperature and soil radiation). Thereafter, as the plant cover and temperature increased, evaporation increased and transpiration took place beside it, then transpiration and evaporation reached maximum values during heading and grain filling stages (March), while at maturity stage the plants tended to be dry and the ETc rate redecreased again during April and May (harvesting). The results of Table (7) indicate that the highest values of ETc rate during all months of the two growing seasons duration (Nov.-May) were resulted from early sowing date (22 Nov.). However, delaying sowing date to 12 Dec. gave the lowest values of daily ETc rates in all growing season months for 2003/2004 and 2004/2005 seasons. It could be revealed that delaying sowing date after 22 Nov. resulted in decreasing the daily ETc rate of wheat during all months of the growing season.

Data presented in Table (7) show that the daily ETc rates of wheat during the growing season months (Nov. to May) of both seasons, were increased by irrigation at 30% ASMD, than the same values resulted from irrigation at 55 or 80% ASMD. It is obvious that increasing the available moisture in wheat root zone (irrigation at short intervals) resulted in increasing the ETc rate during the growing season duration months. These results are in the same line of those reported by **Yousef and Eid (1994) and Yousef and Ashry (2006).**

3. Reference evapotranspiration (ET0)

Reference evapotranspiration rates (ET0) in mm/day during the months of wheat growing seasons, i.e. 2003/2004 and 2004/2005, estimated using the FAO Penman-Monteith method and the meteorological data of Fayoum Governorate are recorded in Table (8).The obtained data indicated that the ET0 rate values were somewhat high during Nov., then decreased during Dec. and Jan. months. Thereafter, the daily rates of ETo increased from Feb. till May, in both seasons. These results may be attributed to the variation in climatic factors from one month to another. **Allen *et al.* (1998)** reported that the reference ET values depend mainly on the evaporative power of the air at each area, i.e. temperature, radiation, relative humidity and wind speed.

4. Crop coefficient (Kc).

The crop coefficient (Kc) reflects the crop cover percentage on the reference ET values. Therefore, the Kc values were calculated from the daily consumptive use rates (Table, 7) and the daily ET0 rates (Table, 8) for each month during the two growing seasons of wheat crop. The results presented in Table (8) show that the Kc values, as a function of sowing dates and irrigation regimes (over all mean) were low during Nov. and Dec. months (initial growth period), then increased during Jan. (0.68 and 0.66) and Feb. (0.81 and 0.79), as the vegetative growth increased to booting stage. The Kc values reached its maximum values, i.e. 0.96 and 0.94 during March (heading-grain filling stage). The Kc values redecreased again during Apr. (0.69 or 0.70), as plants started maturity and reached minimum values on May (0.50 or 0.49) at harvesting.

These results may be attributed to the large diffusive resistance of bare soil during the initial growth stage (germination and seedling stages), which decreased gradually with increasing the crop cover until heading and grain filling stages. At maturity stage (Apr.) the transpiration decreased, as a result of leaves and stem drying causing the low values of Kc during Apr. and May months. The data recorded in Table (8) reveal that delaying sowing date from 22 Nov. to 2 Dec. or 12 Dec. decreased the Kc values during the months of the two growing seasons sowing on 22 Nov. gave the highest Kc values during the growing season months in both seasons. On the other hand, increasing the

Table 7

Table 8

ASMD decreased the Kc values during the growing season months in both season. The highest Kc values during the growing seasons months were resulted from irrigation at 30% ASMD, whereas the lowest ones were detected from irrigation at 80% ASMD. These results were true in both seasons. The Kc values of wheat, as a function of different treatments were 0.51, 0.59, 0.67, 0.80, 0.95, 0.69 and 0.49 for Nov., Dec., Jan., Feb., Mar., Apr. and May, respectively, (average of the two seasons). Such findings are in the same line of those reported by **Doorenbos *et al.* (1979), Yousef and Hanna (1998), and Yousef and Ashry (2006).**

5. Water use efficiency (WUE).

The results presented in Table (9) show that the WUE. values, as affected by sowing date and irrigation regime treatments were; 0.778 and 0.842 kg grains/m^3 water consumed in 2003/2004 and 2004/2005 seasons, respectively. The highest water use efficiency value in 2003/2004 season was 0.782 kg grains/m^3 water consumed, obtained from sowing wheat on 12 Dec. However, in 2004/2005 season, the highest WUE values, i.e. 0.864 kg grains/m^3 water consumed, was detected from 2 Dec. sowing. These results may be referred to that in 2003/2004 season, the grain yield of 12 Dec. sowing was decreased compared to the 2 Dec. sowing by 6.56%, while ETc was decreased by 7.02%. However, in 2004/2005 season the grain yield of 12 Dec. sowing was decreased by 9.41%, while ETc decreased by 6.52%, compared to 2 Dec. sowing .On the other hand, the lowest WUE values, i.e. 0.773 and 0.823 kg grains/m^3 water consumed in 2003/2004 and 2004/2005 seasons, respectively, were obtained from early sowing of 22 Nov. These results found to be true, since the early sowing gave the highest grain yield, but the consumptive use was also higher. It could be concluded that for high grain production when water is more available the early sowing during the 2^{nd} half of Nov., may be preferable, but when water is scarcer, it is preferable to delay sowing to 2 Dec. in order to obtain high WUE. Data listed in Table (9) reveal that the highest WUE values, i.e. 0.844 and 0.897 kg grains/m^3 water consumed in 2003/2004 and 2004/2005 seasons, respectively, were detected from irrigating wheat plants at 55% ASMD. However, irrigation at 80% ASMD gave the lowest WUE values, i.e. 0.657 and 0.751 kg grains/m^3 water consumed in the two successive seasons, respectively.

Irrigation at 30% ASMD decreased WUE values compared to irrigation at 55% ASMD by 1.18% and 2.23% only in 2003/2004 and 2004/2005 seasons, respectively. These results may be due to that irrigation at 55% ASMD decreased grain yield by 4.25% and 4.99%, while seasonal ETc was decreased by 5.38% and 6.95%, in the two successive seasons, compared to irrigation at 30% ASMD. These results are in agreement with those reported by **Abdel-Mottaleb and Metwally (1992), and Yousef and Eid (1999).**

The data recorded in Table (9) show that the WUE values, as a function of the interaction between sowing date and irrigation regime treatments, were different from one season to the another. In the first season, planting wheat on 12 Dec. and irrigation at 55% ASMD gave the highest WUE., i.e. 0.871 kg grains/m^3 water consumed.

However, in the second season, sowing on 2 Dec. and irrigation at 55% ASMD, gave the highest WUE (0.936 kg grains/m^3 water). On the other hand, the lowest WUE values, i.e. 0.626 and 0.737 kg grains/m^3 water consumed were resulted from irrigation at 80% ASMD with 12 Dec. and 22 Nov. sowing dates in 2003/2004 and 2004/2005 seasons, respectively.

Table (9). Effect of sowing date, irrigation regime treatments and their interaction on water use efficiency (kg grains/m^3 water consumed) of wheat crop in 2003/2004 and 2004/2005 seasons.

Sowing dates (D)	2003/2004				2004/2005			
	Irrigation regimes (ASMD)				Irrigation regimes (ASMD)			
	(I_1) 30%	(I_2) 55%	(I_3) 80%	Mean	(I_1) 30%	(I_2) 55%	(I_3) 80%	Mean
(D_1) 22/11	0.807	0.815	0.698	0.773	0.868	0.864	0.737	0.823
(D_2) 2/12	0.844	0.846	0.647	0.779	0.893	0.936	0.764	0.864
(D_3) 12/12	0.850	0.871	0.626	0.782	0.871	0.891	0.751	0.838
Mean	0.834	0.844	0.657	0.778	0.877	0.897	0.751	0.842

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إدارة مياه الري لمحصول القمح تحت مواعيد زراعة مختلفة بالفيوم

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أقيمت التجارب الحقلية بمحطة بحوث كوم أوشيم بالفيوم ـ مصر خلال موسمي الزراعة ٢٠٠٣،٢٠٠٤ / ٢٠٠٥،٢٠٠٤ لدراسة تأثير مواعيد الزراعة (D_1) ٢٢ نوفمبر، (D_2)٢ ديسمبر، (D_3) ١٢ ديسمبر ونظم إدارة مياه الري وذلك بالري عند فقد : (I_1) ٣٠%، (I_2) ٥٥%، (I_3) ٨٠% من الماء الميسر بالتربة علي محصول القمح ومكوناته وبعض العلاقات المائية للمحصول صنف جيزه ١٦٨ . واستخدم تصميم القطع المنشقة مرة واحدة في أربع مكررات وفيما يلي ملخص لأهم النتائج المتحصل عليها:

١ـ أدت زراعة القمح في ٢٢ نوفمبر والري عند فقد ٣٠% من الماء الميسر الى الحصول علي أعلي متوسطات لإرتفاع النبات، عدد السنابل/م٢، وزن الحبوب/م٢، وزن ١٠٠٠ حبه، محصول الحبوب للفدان/فدان (١٥٦٦ ، ١٦٥٦كجم) محصول القش/فدان (٣٦٢٥.٩، ٣٨٢٤.٤ كجم) في ٢٠٠٣ / ٢٠٠٤ ، ٢٠٠٥/٢٠٠٤ علي التوالي . بينما نتجت أقل متوسطات القياسات السابقة من الزراعة في ١٢ ديسمبر والري عند فقد ٨٠% من الماء الميسر في كلا الموسمين.

٢ـ أدي تأخير ميعاد الزراعة من ٢٢ نوفمبر إلي ١٢ ديسمبر إلي نقص معنوي في مكونات المحصول، محصول الحبوب/فدان (١٢.٧% ، ١٢.٤%) ومحصول القش/فدان (٢٤.٧% ، ٢٥.٦%) في

الموسمين المتعاقبين بينما أدت زيادة فقد الماء الميسر من ٣٠% إلي ٨٠% إلي نقص معنوي في مكونات المحصول، محصول الحبوب/فدان بنسبة ٢٩.٧ ، ٢٤.٥%، محصول القش/فدان بنسبة (١١.٩% ، ١٣.٤%) في ٢٠٠٤/٢٠٠٣ ، ٢٠٠٥/٢٠٠٤ علي الترتيب .

٣- كان الإستهلاك المائي الموسمي لجميع معاملات التجربة ٤٠.٤ ، ٣٩.٧سم في موسمي ٢٠٠٤/٢٠٠٣ ، ٢٠٠٥/٢٠٠٤ علي الترتيب وقد أدي تأخير الزراعة من ٢٢ نوفمبر إلي ١٢ ديسمبر وزيادة فقد الماء الميسر بالتربة من ٣٠% إلي ٨٠% إلي خفض الإستهلاك المائي الموسمي من ٤٦.١٨، ٤٥.٤٣ سم إلي ٣٥.٣٥، ٣٤.٨٥سم في الموسمين المتعاقبين علي الترتيب.

٤- بدأ معدل الإستهلاك المائي اليومي بقيم منخفضة خلال نوفمبر وديسمبر ثم إزداد خلال يناير وفبراير ليصل إلي أقصي قيمة له خلال مارس ثم عاود الإنخفاض مرة أخري خلال أبريل وحتي الحصاد في مايو ونقص معدل الاستهلاك المائي اليومي بتأخير ميعاد الزراعة عن ٢٢ نوفمبر وزيادة فقد الماء الميسر في التربة عن ٣٠% في جميع شهور الموسمين. وكانت قيم ثابت المحصول ٠.٥١، ٠.٥٩، ٠.٦٧، ٠.٨٠، ٠.٩٥، ٠.٦٩، ٠.٤٩ (متوسط الموسمين) للشهور نوفمبر، ديسمبر، يناير، فبراير، مارس، أبريل، مايو علي الترتيب.

٥- كانت أعلي قيم لكفاءة إستعمال الماء هي ٠.٨٧١ ، ٠.٩٣٦ كجم حبوب/م٣ ماء مستهلك قد نتجت من الزراعة المتأخرة (١٢ ديسمبر) والري عند فقد ٥٥% من الماء الميسر في ٢٠٠٤/٢٠٠٣، الزراعة في ٢ ديسمبر والري عند فقد ٥٥% من الماء الميسر في ٢٠٠٥/٢٠٠٤ علي الترتيب.