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WATER RELATIONS AND YIELD OF WHEAT UNDER DIFFERENT N- FERTILIZER FORMS AND SCHEDULING IRRIGATION

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ABSTRACT

Field experiment was conducted at Tamia Agric., Res., Station, Fayoum, Egypt during 2008/2009 and 2009/2010 seasons to study the effect of N- fertilizer forms, i.e. F_1: organic form as chicken manure at the rate of $20m^3fed^{-1}$, F_2: bio-fertilizer (biogena)+37.5 kg mineral N as ammonium nitrate 33.0% N and F_3: mineral N fertilizer at the rate of 75 kg N fed^{-1} (as ammonium nitrate 33.0% N) and scheduling irrigation treatments, i.e. I_1: irrigation at 0.8 cumulative pan evaporation (C.P.E.), I_2: irrigation at 1.0 and I_3: irrigation at 1.2 C.P.E. on yield, yield components and some water relations of wheat crop (Giza 168 cv.). A split-plot design with four replicates was used since N- fertilizer forms were represented in the main plots while scheduling irrigation treatments were occupied the split ones.

The main obtained results were as follows:

1- Using mineral N form and irrigation at 1.2 C.P.E. gave the highest averages of spike numbers m^{-2}, 1000-grain weight, grain yield fed^{-1}. (2149.28 and 2271.50 kg fed^{-1}) and straw yield (2619.60 and 2775.85 kg fed^{-1}) in the two successive seasons, but plant height was affected significantly in the second season only. The lowest averages of yield and its components were obtained from using organic fertilizer(chicken manure) form and irrigation at 0.8 C.P.E. in both seasons.

2- Seasonal consumptive use (ET_C) averaged 39.23 and 41.83 cm in 2008/2009 and 2009/2010 seasons, respectively. The highest ET_C values, i.e. 44.12 and 46.36 cm were recorded with the interaction (F_3I_3), whereas the lowest values as 35.65 and 38.72 cm resulted from the interaction (F_1I_1), in 2008/2009 and 2009 /2010, respectively,

3- Daily ET_C rates were low during Nov. and Dec., then increased during Jan. and Feb., to reach its maximum values during March and then declined again at April till harvesting. The values of daily ET_C decreased due to organic or bio-fertilizer forms in the two growing season's months. The crop coefficient (K_C) values (averages of the two seasons) were 0.53, 0.61, 0.70, 0.79, 0.93, 0.61 and 0.52 for, Nov., Dec., Jan., Feb., Mar., Apr. and May, respectively.

4- The highest water use efficiency, i.e. 1.27 and 1.29 kg grain m^{-3} water consumed were obtained from the interaction of (F_3I_3) in 2008/2009 and 2009/2010 seasons, respectively.

Keywords: Wheat yield, yield components, N fertilizer forms, scheduling irrigation and water relations.

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INTRODUCTION

Wheat is one of the most important cereal food crops in the world. In Egypt, its production doesn't meet the current demand, so, the Egyptian government is doing more efforts to reduce the imported percentage to be less than 50% from the total consumption.

Wheat production is affected by different factors such as climatic condition, irrigation and soil fertility....etc. The new reclaimed areas are in continuous increase and the limited irrigation water resources are being the most detrimental factor. The interaction between fertilization and irrigation is considered one of the most important factor affecting wheat production. Adding N fertilizers tends to produce high grain and straw yield, regardless of quantity or distribution of water. Wang *et al.* (2001), Sardana *et al.* (2002) and Camara *et al.* (2003) indicated that low inorganic N applications (0 or 31 kg ha^{-1}) resulted in low yields even at a high level of organic fertilizer (corn stover + cattle manure > 4500 kg ha^{-1}) and the yield was also limited by lack of organic fertilizer application even at an inorganic fertilizer rate of 105 kg ha^{-1}. Therefore, to overcome the problem of nutrient deficiency and to increase wheat yield, the farmers are applying chemical fertilizers. However, the chemical fertilizers are expensive and the small farmers cannot afford to use these fertilizers in suitable amount and balanced proportion (Ahmed, 2000). Under such condition integrated use of chemical and organic fertilize/manure can play an important role to sustain soil fertility and crop productivity (Tandon, 1998 and Lampe, 2000). Application of organic manures or some organic wastes alone was found to be useful (Ibrahim *et al.* 1992 and Alam and Shah 2003), but integrated use of organic wastes and chemical fertilizers has proved more rewarding (Mian *et al.* 1989, Nasir and Qureshi 1999, Khanam *et al.* 2001 and Alam *et al.* 2003 and 2005). Shaaban (2006) studied the effect of two sources of organic fertilizer (chicken manure, sunflower residue), and different levels of inorganic nitrogen fertilizer and concluded that the maximum values of water use efficiency (WUE) for grains and straw yields of wheat were observed by increasing doses of inorganic N fertilizer and decreased by deceasing the N fertilizer.

Regarding the irrigation scheduling 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 induced a moderate stress while a sever stress was occurred as ASMD exceeded 80%. Water requirements for high yield ranged between 45 and 65 cm, and the crop coefficient (K_C) values were 0.3-0.4, 0.7-0.8, 1.05-1.2, 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. Moreover, Yousef and Eid (1994) ,in Fayoum, reported that the highest values of wheat yield and its components were obtained from irrigation at 30% ASMD, and increasing ASMD from 50% to 70% significantly decreased yield components, grain yield and straw yield. Value of ET_C 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^{-1}, 1000-grain weight and grain straw yields fed^{-1} were significantly decreased by increasing ASMD from 35% to 70%, and seasonal ET_C were 42.77 and 37.83 cm, respectively. Values of K_C 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, respectively. The highest WUE was resulted from irrigation at 35% ASMD. In connection, 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^{-1}, seasonal ET_C (43.7 cm) and WUE (1.065 kg grains m^{-3} water consumed), whereas, irrigation at 80% gave the lowest mentioned measurements. Hussain *et al.* (2003) indicated that irrigation of wheat at 4 weeks after emergence gave the highest number of spikes m^{-3}, however, irrigation at 2 weeks after emergence gave the highest grain and biological yields .Yousef and Ashry (2006) found that the highest wheat 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 ET_C 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 K_C 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, respectively.

The present trial aiming at determining the effect of scheduling irrigation, via pan evaporation records, under different nitrogenous fertilizer forms on wheat yield, yield components and some crop – water relations.

MATERIALS AND METHODS

The present investigation was conducted during 2008/2009 and 2009/2010 seasons at Fayoum Agric. Res. Station (Tameia). The soil physical and chemical properties of the experimental site as determined according to Klute (1986) and Page *et al.* (1982) are presented in Table (1). The trials aiming at studying the effect of different N fertilizer forms and irrigation scheduling treatments and their interaction on yield, yield components and some crop -water relations. Three fertilizer forms, i.e. F_1: organic, as chicken manure at the rate of $20m^3$ fed^{-1}, F_2: bio fertilizer (biogena)+37.5 kg N fed^{-1} as ammonium nitrate 33.0% N, F_3: mineral N form (as ammonium nitrate,33.0% N) were combined with three irrigation scheduling treatments, i.e. I_1: irrigation at 0.8 cumulative pan evaporation (C.P.E.), I_2: irrigation at 1.0 C.P.E., and I_3: irrigation at 1.2 C.P.E. The adopted treatments were assessed in split- plot experimental design with four replicates. The main plots were allocated for N-fertilization forms while the split ones were occupied by the irrigation scheduling treatments. The sub -plot, area was 21.0 m^2 (3.0×7.0 m).

Table (1): Physical and chemical analysis of the experimental field during 2008/2009 and 2009/2010 seasons (average of two seasons) for all studied depths.

Physical analysis				Chemical analysis	
Sand%	Silt%	Clay%	Texture classes	Organic matter%	$CaCO_3$%
40.8	21.2	38.00	Clay loam	1.68	5.18

Chemical analysis														
Soluble cations, (meq/L)				Soluble anions (meq/L)				CEC (meq/ 100 g soil)	pH (1:2.5) Extract	Ec, dSm^{-1}	Exchangeable Cations, meq/100 gm soil			
Ca^{++}	Mg^{+}	Na^{+}	K^{+}	Cl^{-}	HCO_3^{-}	CO_3^{--}	SO_4^{--}				Na+	K^{+}	Mg^{++}	Ca^{++}
8.18	7.69	24.67	0.33	2037	3.06	-	17.08	32.47	8.12	4.00	4.05	1.2	10.29	16.29

The traditional irrigation scheduling aiming at managing the water in more efficient manner via conveying the irrigation water to the crop timely and quantitatively in order to match the crop water needs and to conserve the water resources too. In the present study, pan evaporation record was multiplying by the different assessed coefficient to induce variation in both time of irrigation and the applied water quantity for each irrigation event to find out the proper coefficient resulted in the wheat yield potential and improve water use efficiency as well. It is well known that the weather elements e.g. solar radiation, air temperature, wind velocity and air relative humidity are influencing both the crop evapotranspiration and pan evaporation in the same manner. So irrigation must be practiced as the two sides of the following formula are the same:-

Pan evaporation record, mm x Coefficient = Available soil water in the root zone (60 cm depth), mm

The N-fertilizer rate of 75kg N fed^{-1} was applied in three equal doses (at planting and just before 1st and 2nd irrigations). Calcium super phosphate (15.5% P_2O_5) was added as a basal dose of 150 kg fed^{-1} during the field preparation. The organic fertilizer (chicken manure) was applied during field preparation at rate of 20 m^3 fed^{-1}. The chicken manure contains 2.8% N, by weight, as determined according to Jackson (1967). Each plot was isolated from the others by allays 1.5 m between to avoid the lateral movement of water. The averages of climatic factors for Fayoum Governorate during the wheat crop growing seasons are recorded in Table (2). Dates of irrigation and irrigations count for different treatments ,in both seasons, are listed in Table (3). Irrigation scheduling treatments started at the 2nd irrigation. Wheat seeds of Giza 168 cv., at seeding rate of 70 kg fed^{-1}, were planted on November20th, whereas harvesting was done on May 5th in the two successive seasons. The wheat seeds were inoculated with the bio-fertilizer (biogena) half an hour before planting as recommended .

Table (2): The monthly averages of climatic factors for Fayoum Governorate during 2008/2009 and 2009/2010 seasons.

Month	season	Temperature C°			Relative Humidity%	Wind Speed, m sec^{-1}.	Class A pan Evaporation, mm day^{-1}
		Max.	Min.	Mean			
November	2008	26.6	13.1	19.85	52	1.49	2.9
	2009	25	11.7	18.35	52	1.48	2.5
December	2008	22.2	9.1	15.65	54	1.03	1.6
	2009	22.4	8.9	15.65	53	1.05	1.9
January	2009	20.7	6.7	13.70	53	1.2	1.7
	2010	21.9	7.6	14.80	53	1.18	1.8
February	2009	22.3	6.4	14.35	48	1.65	2.5
	2010	24.4	8.2	16.30	49	1.65	2.8
March	2009	23.2	7.9	15.55	49	2.11	4.4
	2010	27.5	11.4	19.50	50	2.13	4.3
April	2009	30.8	12.5	21.65	46	2.42	5.1
	2010	31.8	14.3	23.00	46	2.43	5.9
May	2009	32.8	16.7	24.75	46	2.78	6.9
	2010	34.1	16.7	25.40	45	2.77	6.9

Table (3): Dates and irrigations number of wheat as affected by N fertilizer forms and irrigation scheduling treatments in 2008/2009 and 2009/2010 seasons.

Number of irrigation	2008/2009 season									2009/2010 season								
	F_1			F_2			F_3			F_1			F_2			F_3		
	0.8	1.0	1.2	0.8	1.0	1.2	0.8	1.0	1.2	0.8	1.0	1.2	0.8	1.0	1.2	0.8	1.0	1.2
	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date
Planting	20/11	20/11	20/11	20/11	20/11	20/11	20/11	20/11	20/11	20/11	20/11	20/11	20/11	20/11	20/11	20/11	20/11	20/11
1st irrigation	11/12	11/12	11/12	11/12	11/12	11/12	11/12	11/12	11/12	12/12	12/12	12/12	12/12	12/12	12/12	12/12	12/12	12/12
2nd	11/1	5/1	31/12	11/1	5/1	31/12	11/1	5/1	31/12	13/1	7/1	1/1	13/1	7/1	1/1	13/1	7/1	1/1
3rd	13/2	30/1	20/1	13/2	30/1	20/1	13/2	30/1	20/1	15/2	31/1	22/1	15/2	31/1	22/1	15/2	31/1	22/1
4th	17/3	25/2	6/2	17/3	25/2	6/2	17/3	25/2	6/2	19/3	27/2	8/2	19/3	27/2	8/2	19/3	27/2	8/2
5th	20/4	21/3	26/2	20/4	21/3	26/2	20/4	21/3	26/2	21/4	23/3	1/3	21/4	23/3	1/3	21/4	23/3	1/3
6th	-	15/4	17/3	-	15/4	17/3	-	15/4	17/3	-	17/4	19/3	-	17/4	19/3	-	17/4	19/3
7th	-	-	5/4	-	-	5/4	-	-	5/4	-	-	7/4	-	-	7/4	-	-	7/4
Harvesting	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5
Irrigations count	5	6	7	5	6	7	5	6	7	5	6	7	5	6	7	5	6	7

The soil moisture was gravimetrically determined on the oven dry basis for soil layers, each of 15 cm depth to 60 cm depth of the soil profile. Some of the soil moisture constants are shown in Table (4).

Table (4): Some soil moisture constants for the experimental field during 2008/2009 and 2009/2010 seasons (average of the two seasons).

Soil depth (cm)	Field capacity (%,wt/wt)	Wilting point (%,wt/wt)	Bulk density (Kg m^{-3})	Available moisture (%wt/wt)	Available Water (mm depth)
00-15	42.46	21.06	1.41	21.4	45.3
15-30	40.73	19.81	1.43	20.92	44.9
30-45	38.12	18.55	1.31	19.57	38.5
45-60	36.55	18.32	1.39	18.23	38.0

At harvesting time, the following data were collected for each sub-plot.

Yield and yield components:

1- Plant height (cm).

2- Spike number m^{-2}.

3- 1000-Grain weight (g).

4- Grain yield: The yield of the whole sub-plot was harvested and expressed as kg fed^{-1}.

5- Straw yield: The yield of the whole sub-plot was harvested and expressed as kg fed^{-1}.

All the collected data were subjected to the statistical analysis according to Snedecor and Cochran (1980) and the means were compared by L.S.D. test at 5% level.

Crop water relations:

Seasonal consumptive use (ET_C).

The crop water consumptive use (ET_C) was determined via soil sampling each sub-plot, just before and after 48 hours from each irrigation, as well as at harvesting time, and the ET_C between each two successive irrigations was calculated according to Israelsen and Hansen, 1962 as follows:

$$Cu\ (ET_C) = \{(Q_2 - Q_1) / 100\} \times Bd \times D \text{ .... Where:}$$

Cu = Crop water consumptive use (cm).

Q_2= Soil moisture percentage 48 hours after irrigation.

Q_1= Soil moisture just before irrigation.

Bd = Soil bulk density (g cm^{-3}).

D = Soil layer depth (cm).

Daily ET_C rate (mm day^{-1}).

Calculated from the ET_C between each two successive irrigations divided by the number of days.

Reference evapotranspiration (ET_0)

Estimated as a monthly rate (mm day^{-1}), using the monthly averages of climatic factors of Fayoum Governorate and the procedures of the FAO-Penman Monteith equation (Allen *et al.* 1998)

Crop Coefficient (K_C).

The crop coefficient was calculated as follows:

$K_C = ET_C / ET_0$ ....

Where:

ET_C = Actual crop evapotranspiration (mm day^{-1})

ET_0 = Reference evapotranspiration (mm day^{-1}).

Water Use Efficiency (WUE).

The water use efficiency as kg grains m^{-3} water consumed was calculated for different treatments as described by Vites (1965) as follows:

WUE,(kg m^{-3}) = Grain yield (kg fed^{-1}) ÷ Seasonal ET_C (m^3 fed^{-1})

RESULTS AND DISCUSSION

Yield and yield components:

Yield components.

The results presented in Table (5) reveal that N fertilizer forms significantly affected wheat yield components in both seasons, except plant height in 2008/2009 season. Mineral N fertilizer gave the highest averages of spike number m^{-2} and 1000-grain weight in the two seasons, as well as plant height in 2009/2010 season. Bio-fertilizer +37.5 kg N fed^{-1} as Amm. Nitrate significantly decreased spike number m^{-2} and 1000-grain weight in 2008/2009 by 4.1 and 3.14% and in 2009/2010 season by 7.31 and 3.45%, respectively, and plant height was decreased by 4.3% , as compared with mineral N fertilizer. Moreover, organic N fertilizer (chicken manure) alone significantly reduced spike number m^{-2}, and 1000-grain weight in 2008/2009 season by 9.10 and 4.49%, respectively, while plant height didn't significantly differ. In 2009/2010 season plant height, spike number m^{-2} and 1000-grain weight were reduced by 7.57, 12.15 and 4.31%, respectively, compared with mineral N fertilizer. These results may be due to that N in mineral fertilizer as a nutrient element is easily available to the crop than N in the organic forms. The obtained results are in consistent with those found by Mian *et al.* (1989), Ibrahim *et al.* (1992), Tandon (1998), Nasir and Qureshi (1999), Ahmed (2000), Lampe (2000), Khanam *et al.* (2001) and Alam and Shah (2003).

Regarding the effect of scheduling irrigation treatments, data in Table (5) show that wheat yield components were significantly affected by irrigation scheduling treatments in both seasons. Irrigation wheat plant at 1.2 (C.P.E.) gave the highest averages of yield components, whereas irrigation at 0.8 C.P.E. gave the lowest ones in both seasons. Increasing irrigation scheduling coefficient from 0.8 to 1.2 C.P.E. significantly increased plant height, spike number m^{-2} and 1000-grain weight in 2008/2009 season by 10.86, 17.31 and 2.47%, respectively, and in 2009/2010 season by 10.85, 20.84 and 2.79%, respectively. These results may be referred to the effect of moisture stress(under 0.8 C.P.E. treatment) on reducing photosynthesis, cell division, stem elongation, leaf area, leaf duration, tillering and dry matter accumulation in plant organs. The obtained results are in the same line with those reported 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).

Table (5): Effect of N fertilizer forms and irrigation scheduling treatments on yield and yield components of wheat crop in 2008/2009 and 2009/2010 seasons.

Treatments		2008/2009 season					2009/2010 season				
Fertilization	Irrigation (PEC)	Plant Height (cm)	Spike Number m^{-2}	1000-Grain weight (g)	Grain yield fed^{-1} (kg)	Straw yield fed^{-1} (kg)	Plant Height (cm)	Spike Number m^{-2}	1000-Grain weight(g)	Grain yield fed^{-1} (kg)	Straw yield fed^{-1} (kg)
F_1	I_1: 0.8	81.33	310.67	45.18	1350.65	1650.96	83.00	317.7	45.55	1364.37	1666.80
	I_2:1.0	85.67	368.33	45.30	1658.95	2026.53	87.00	382.7	45.71	1692.13	2068.33
	I_3:1.2	91.67	402.67	45.54	1721.27	2104.53	93.70	425.3	45.92	1772.91	2165.46
Mean		86.22	360.56	45.34	1576.96	1927.34	87.90	375.2	45.73	1609.80	1966.86
F_2	I_1: 0.8	85.00	361.33	45.57	1760.29	2150.77	86.70	356.3	45.65	1795.50	2193.97
	I_2:1.0	88.67	370.00	45.78	1925.71	2352.17	91.00	402.3	45.82	2002.87	2446.96
	I_3:1.2	95.33	409.67	46.58	2117.11	2586.90	96.70	429.0	46.94	2176.50	2655.90
Mean		89.66	380.33	45.98	1934.37	2363.28	91.00	395.9	46.14	1991.62	2432.28
F_3	I_1: 0.8	88.00	366.00	46.44	1914.44	2340.17	89.30	378.0	46.65	1968.00	2406.10
	I_2:1.0	94.00	381.00	47.43	2186.01	2650.23	96.00	428.7	47.79	2341.50	2860.43
	I_3:1.2	98.33	443.00	48.54	2347.39	2868.40	100.00	474.7	48.94	2505.00	3061.03
Mean		93.44	396.67	47.47	2149.28	2619.60	95.10	427.1	47.79	2271.50	2775.85
	I_1: 0.8	84.78	346.00	45.73	1652.62	2047.30	86.30	350.7	45.95	1709.29	2088.90
	I_2:1.0	89.45	373.11	46.17	1923.56	2342.98	91.30	404.6	46.44	2012.17	2458.57
	I_3:1.2	95.11	418.45	46.89	2061.92	2519.94	96.80	443.0	47.27	2151.47	2627.46
L.S.D.: 5%											
F.		N.S	3.65	0.13	130.73	27.79	2.26	13.70	0.23	117.88	23.43
I.		2.6	8.87	0.14	94.68	14.86	8.94	9.70	0.22	76.90	9.22
FxI		N.S	15.36	0.24	N.S	25.74	N.S	16.80	0.38	N.S	15.96

Data in Table (5) indicate that yield components were significantly affected by the interaction between the forms of N fertilizer and irrigation scheduling treatments except plant height in both seasons. The highest averages of spike number/m^2, 1000-grain weight were detected from mineral N fertilizer as interacted with irrigation at 1.2 C.P.E. in both seasons. On the other hand, the lowest averages of yield components were resulted from organic manure (chicken manure) as interacted with irrigation at 0.8 C.P.E. in both seasons.

Grain and Straw yields.

Results in Table (5) reveal that the averages of grain and straw yields were significantly differed due to different N fertilizer forms in both seasons. The mineral N fertilizer gave the highest grain yields, i.e. 2149.28 and 2271.50 kgfed^{-1} and the highest straw yields of 2619.60 and 275.85 kg fed^{-1}, in 2008/2009 and 2009/2010 seasons, respectively. Bio-fertilizer +37.5 kg N fed^{-1} as Ammonium Nitrate fertilizer significantly decreased grain yield by 10.0 and 12.32% and straw yields by 9.78 and 12.38% in the two successive seasons, respectively, comparable with mineral N fertilizer. Organic fertilizer (chicken manure) alone significantly decreased the grain yields by 26.63 and 29.13% and straw yields by 26.43 and 29.14% in the two successive seasons, respectively, as compared with mineral N fertilizer. These results may be attributed to that the mineral N fertilizer was superior to improve all of yield components and plant height than the organic source because its N content is soluble and ready to be absorbed by plant. These results are in harmony with those reported by Ahmed (2000) and Alam *et al.* (2003 and 2005).

Concerning the effect of scheduling irrigation treatments, data in Table (5) indicate that scheduling irrigation had significant effects on grain and straw yields in both seasons. Irrigation at 1.2 C.P.E. gave the highest averages of grain and straw yields in 2008/2009 season which amounted to 2061.92 and 2519.94 kg fed^{-1} and reached 2151.47 and 2627.46 kg fed^{-1} in 2009/2010 season, respectively. Grain and straw yields were reduced by 6.71 and 7.02 % in 2008/2009 and by 6.47 and 6.43%, in 2009/2010, respectively, as irrigation was practiced at 1.0 C.P.E. In addition, more decreases in grain and straw yields amounted to 19.85 and 18.76% in 2008/2009 and 20.55 and 20.50% in 2009/2010 season, respectively, due to irrigating at 0.8 C.P.E., compared with irrigation at 1.2 C.P.E. Such finding may be attributed to the effect of water stress on reducing growth attributes (plant height), spike number m^{-2} and 1000-grain weight as yield components. These results are in agreement with those found by Doorenbos *et al.* (1979), Yousef and Hanna (1998), Hussain *et al.* (2003) and Yousef and Ashry (2006).

Results in Table (5) show that wheat grain yield didn't significantly affect by the interaction between N fertilizer forms and scheduling irrigation treatments, however, higher grain yields i.e. 2347.39 and 2505.0 kg fed^{-1} were observed as N mineral fertilizer interacted with irrigation at 1.2 C.P.E. On the contrary, straw yield was significantly affected by such interaction. The highest straw yield, i.e. 2868.40 and 3061.03 kg fed^{-1} in 2008/2009 and 2009/2010 seasons, respectively, were obtained as N mineral fertilizer interacted with irrigation at 1.2 C.P.E. Nevertheless, the lowest grain yields of 1350.65 and 1364.37 kg fed^{-1} and the lowest straw yields of 1650.96 and 1666.8 kg fed^{-1} in 2008/2009 and 2009/2010 seasons, respectively, were recorded for organic fertilizer as interacted with irrigating at 0.8 C.P.E.

Crop - water relations

Seasonal consumptive use (ET_C).

Results presented in Table (6) indicate that seasonal consumptive use or evapotranspiration (ET_C) of wheat crop, as a function of N fertilizer forms and scheduling irrigation treatments were, 39.23 and 41.83 cm in 2008/2009 and 2009/2010 seasons, respectively. The difference may be due to the variation in climatic factors of the two seasons (Table, 2) and higher grain and straw yields in 2009/2010 season. Mineral N fertilizer treatment gave the highest values of wheat ET, i.e. 41.81 and 44.13 cm in two successive seasons. Bio-fertilizer+37.5 kg N, as Amm. Nitrate fertilizer or organic fertilizer (chicken manure) decreased seasonal ET_C in 2008/2009 season by 6.51 and 12.03% and by 5.10 and 10.54% in 2009/2010 season, respectively. It is obvious, that bio or organic forms resulted in lower seasonal consumptive use. These results may be referred to the lower performance of wheat crop under such fertilizer forms in the present research trial.

Table (6): Effect of N fertilizer forms and irrigation scheduling on seasonal water consumptive use of wheat crop (ET_C, cm)

Fertilizer forms	2008/2009 season				2009/2010 season			
	Irrigation scheduling			Mean	Irrigation scheduling			Mean
	0.8 PEC	1.0 PEC	1.2 PEC		0.8 PEC	1.0 PEC	1.2 PEC	
F_1	35.65	36.94	37.75	36.78	38.05	39.72	40.66	39.48
F_2	37.17	38.88	41.22	39.09	40.13	42.03	43.48	41.88
F_3	39.34	41.98	44.12	41.81	41.83	44.20	46.36	44.13
Mean	37.41	39.27	41.03	39.23	40.00	41.98	43.50	41.83

Regarding the effect of scheduling irrigation treatments, data in Table (6) show that irrigating wheat at 1.2 C.P.E. produced the highest values of ET_C which reached 41.03 and 43.50 cm in 2008/2009 and 2009/2010 seasons, respectively. The lowest ET_C values, e.g. 37.41 and 40.98 cm were resulted from irrigating at 0.8 C.P.E. in the two successive seasons. Moreover, irrigation at 1.0 C.P.E. decreased ET_C by 4.48 and 3.49% in 2008/2009 and 2009/2010 seasons, respectively, comparable with irrigating at 1.2 C.P.E.. It could be concluded that increasing the available soil moisture in the root zone of wheat plants, under irrigation at 1.2 C.P.E. treatment, caused increases in ET_C throughout the season. Higher both transpiration rate from plants canopy and evaporative demands from soil surface under higher available soil moisture are responsible for higher ET_C values . Under water stress, irrigating at 1.0 or 0.8 C.P.E., 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), Yousef and Hanna (1998) and Yousef and Ashry (2006).

Data in Table (6) indicate that mineral N fertilizer under irrigation at 1.2 C.P.E. gave the highest values of ET_C which comprised 44.12 and 46.36 cm in 2008/2009 and 2009/2010 seasons, respectively. Nevertheless, the lowest ET_C values, e.g. 35.65 and 38.05 cm in the two successive seasons were detected from interaction between organic fertilizer (chicken manure) and irrigation at 0.8 C.P.E.

Daily ET_C (mm/day).

The results in Table (7) show that the daily ET_C rates as influenced by different tested treatments in both seasons were started with low values during Nov. and decreased more during Dec. and then increased again during Jan. and Feb. to reach its 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 (germination and seedling stages), most of the water loss is due to evaporation from the bare soil and the reduction in ET_C rate during Dec. was due to the decrease in evaporative demands (temperature and solar radiation). Thereafter, as both 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). At maturity stage the plants tended to be dry and the ET_C rate redecreased again during April and May (harvesting). The results of Table (7) indicate that the highest values of ET_C were during (Nov. – May) which resulted from applying mineral N fertilizer. On the contrary,, applying organic fertilizer(chicken manure) gave the lowest values of daily ET_C rate during entire growing seasons of 2008/2009 and 2009/2010.

Data in Table (7) show that the daily ET_C rates of wheat during the growing season months (Nov. – May) of both seasons, were increased by irrigation at 1.2 C.P.E., while with irrigation at 1.0 , or 0.8 C.P.E. the figures tended to decrease. It is obvious that increasing the available moisture in wheat root zone (irrigation at short interval) resulted in increasing the ETC rate during the growing season. These results are in the same line of those reported by Yousef and Eid (1994) and Yousef and Ashry (2006).

Reference evapotranspiration (ET_0).

Reference evapotranspiration rate (ET_0) in mm day^{-1} during the months of wheat growing seasons, i.e. 2008/2009 and 2009/2010, estimated using the FAO Penman- Monteith method via the meteorological data of Fayoum Governorate Table (8). Data indicate that the ET_0 rate values were somewhat high during Nov., and then decreased during Dec. and Jan. months. Thereafter, the daily rates of ET_0 increased from Feb. till May, in both seasons. These results are 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.

Table (7): N fertilizer forms and irrigation scheduling treatments and their interactions on daily water consumptive use (mm day^{-1}) in 2008/2009 and 2009/2010 seasons.

Treatments		2008/2009 season							2009/2010 season						
		Nov.	Dec.	Jan.	Feb.	March	Apr.	May	Nov.	Dec.	Jan.	Feb.	March	Apr.	May
F_1	0.8 PEC	1.48	1.46	1.78	2.26	3.26	3.08	2.77	1.37	1.30	1.55	2.38	3.40	3.05	2.90
	1.0 PEC	1.51	1.48	1.84	2.39	3.37	3.19	2.95	1.43	1.37	1.65	2.55	3.53	3.08	2.96
	1.2 PEC	1.54	1.53	1.89	2.42	3.44	3.25	3.01	1.46	1.42	1.68	2.62	3.61	3.14	3.09
	Mean	**1.51**	**1.50**	**1.84**	**2.36**	**3.18**	**3.70**	**2.91**	**1.42**	**1.36**	**1.67**	**2.56**	**3.58**	**3.45**	**3.06**
F_2	0.8 PEC	1.51	1.48	1.84	2.39	3.44	3.19	2.95	1.40	1.34	1.68	2.48	3.53	3.25	3.21
	1.0 PEC	1.54	1.53	1.89	2.48	3.59	3.47	3.13	1.46	1.44	1.73	2.55	3.66	3.47	3.28
	1.2 PEC	1.60	1.56	2.00	2.60	3.96	3.64	3.19	1.48	1.46	1.80	2.75	3.78	3.53	3.40
	Mean	**1.55**	**1.54**	**1.89**	**2.46**	**3.49**	**3.85**	**3.11**	**1.45**	**1.41**	**1.74**	**2.69**	**4.04**	**3.68**	**3.30**
F_3	0.8 PEC	1.57	1.56	1.92	2.54	3.63	3.47	3.07	1.46	1.42	1.73	2.58	3.61	3.47	3.28
	1.0 PEC	1.60	1.59	2.00	2.70	4.07	3.64	3.30	1.51	1.44	1.83	2.69	4.00	3.58	3.34
	1.2 PEC	1.65	1.61	2.16	2.82	4.26	3.92	3.36	1.54	1.51	1.90	2.79	4.34	3.70	3.47
	Mean	**1.59**	**1.57**	**1.95**	**2.53**	**3.71**	**4.07**	**3.25**	**1.50**	**1.46**	**1.82**	**2.85**	**4.39**	**3.90**	**3.38**
Mean of irri.															
0.8 PEC		1.52	1.50	1.85	2.39	3.44	3.25	2.93	1.41	1.35	1.65	2.48	3.51	3.26	3.13
1.0 PEC		1.55	1.53	1.91	2.52	3.77	3.43	3.13	1.47	1.42	1.74	2.60	3.73	3.38	3.19
1.2 PEC		1.60	1.57	2.02	2.61	3.89	3.60	3.19	1.49	1.46	1.80	2.72	3.91	3.46	3.32
Over all mean		**1.56**	**1.53**	**1.93**	**2.51**	**3.70**	**3.43**	**3.08**	**1.46**	**1.41**	**1.73**	**2.60**	**3.72**	**3.37**	**3.21**

Table (8): Effect of N fertilizer forms and irrigation scheduling treatments on crop coefficient (K_C) of wheat crop in season months.

Treatments		2008/2009 season							2009/2010 season						
Fert. forms	Irri. Sched.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
Reference ET(ET_0)		2.9	2.6	2.7	3.1	3.7	5.6	5.9	2.8	2.4	2.5	3.4	4.3	5.6	6.3
F_1	I_1: 0.8	0.51	0.56	0.66	0.73	0.88	0.55	0.47	0.49	0.54	0.62	0.70	0.79	0.54	0.46
	I_2: 1.0	0.52	0.58	0.68	0.77	0.91	0.57	0.50	0.51	0.57	0.66	0.75	0.82	0.55	0.50
	I_3: 1.2	0.53	0.59	0.70	0.78	0.96	0.60	0.51	0.52	0.59	0.67	0.77	0.84	0.56	0.51
Mean		**0.52**	**0.58**	**0.68**	**0.76**	**0.92**	**0.57**	**0.49**	**0.51**	**0.57**	**0.65**	**0.74**	**0.82**	**0.55**	**0.49**
F_2	I_1: 0.8	0.52	0.58	0.68	0.77	0.93	0.57	0.50	0.50	0.56	0.67	0.73	0.82	0.58	0.51
	I_2: 1.0	0.53	0.59	0.70	0.80	0.97	0.62	0.53	0.52	0.60	0.69	0.76	0.85	0.62	0.52
	I_3: 1.2	0.55	0.62	0.74	0.84	1.07	0.65	0.54	0.53	0.61	0.72	0.81	0.88	0.63	0.54
Mean		**0.53**	**0.60**	**0.71**	**0.80**	**0.99**	**0.61**	**0.52**	**0.52**	**0.59**	**0.69**	**0.77**	**0..85**	**0.61**	**0.52**
F_3	I_1: 0.8	0.54	0.60	0.71	0.82	0.98	0.62	0.52	0.52	0.59	0.69	0.76	0.84	0.62	0.52
	I_2: 1.0	0.55	0.61	0.74	0.87	1.10	0.65	0.56	0.54	0.61	0.73	0.79	0.93	0.64	0.53
	I_3: 1.2	0.57	0.64	0.80	0.91	1.15	0.70	0.57	0.55	0.63	0.76	0.82	1.01	0.66	0.55
Mean		**0.55**	**0.62**	**0.75**	**0.87**	**1.08**	**0.66**	**0.55**	**0.54**	**0.61**	**0.73**	**0.79**	**0.93**	**0.64**	**0.53**
Means of Irri.															
I_1: 0.8		0.52	0.58	0.68	0.77	0.93	0.58	0.50	0.50	0.56	0.66	0.73	0.82	0.58	0.50
I_2: 1.0		0.53	0.59	0.71	0.81	0.99	0.61	0.53	0.52	0.59	0.69	0.77	0.87	0.60	0.52
I_3: 1.2		0.55	0.62	0.75	0.84	1.06	0.65	0.54	0.53	0.61	0.72	0.80	0.91	0.62	0.53
Over all mean		**0.53**	**0.60**	**0.71**	**0.81**	**0.99**	**0.61**	**0.52**	**0.52**	**0.62**	**0.69**	**0.77**	**0.87**	**0.60**	**0.52**

Crop coefficient (K_C).

The crop coefficient (K_C) reflects the crop cover percentage on the reference ET values. Therefore, the K_C values of wheat crop were calculated from the daily consumptive use rates (Table, 7) and the daily ET_0 rates (Table, 8) for each month during the two growing seasons. The results presented in Table (8) show that the K_C values, as a function of fertilizer forms and scheduling irrigation treatments (over all mean) were low during Nov. and Dec. (initial growth period), then increased during Jan. (0.71 and 0.69) and Feb. (0.81 and 0.77), as the vegetative growth increased to booting stage. The K_C values reached its maximum values, i.e. 0.99 and 0.87during March (heading and grain filling stages). The K_C values redecreased again during Apr. (0.61 and 0.60), as plants started maturity and reached minimum values on May (0.52 and 0.52) 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 K_C during Apr. and May months. Data in Table (8) reveal that applying mineral N fertilizer gave the highest K_C values, while bio-fertilizer+37.5 kg N fed^{-1} as Amm. Nitrate fertilizer or organic fertilizer (chicken manure) decreased the K_C values during the months of the two growing seasons. The highest K_C values during the growth seasons months were resulted from irrigation at 1.2 C.P.E., whereas the lowest ones were detected from irrigation at 0.8 C.P.E. and these results were true in both seasons. The K_C values of wheat, as a function of the adopted treatments were 0.53, 0.61, 0.70, 0.79, 0.93 0.61 and0.52 for Nov., Dec., Jan., Feb., March, 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).

Water use efficiency (WUE).

Results in Table (9) show that WUE values, as affected by fertilizer forms and scheduling irrigation treatments were: 1.14 and 1.10 kg grain m^{-3} water consumed in 2008/2009 and 2009/2010 seasons, respectively. The highest water use efficiency values of 1.22 and 1.22 kg grain m^{-3} water consumed were obtained from mineral N fertilizer in both seasons. On the other hand, the lowest WUE values, of 1.02 and 0.97 kg grain m^{-3} water consumed in 2008/2009 and 2009/2010 seasons, respectively, were obtained from applying organic fertilizer (chicken manure). These results are referred to that in 2008/2009 season, the grain yield, obtained from applying organic fertilizer (chicken manure) was decreased by 26.63%, while ET_C was decreased by 12.03%. In addition, in 2009/2010 season grain yield was decreased by 29.13%, while ET_C was decreased by 10.54%, as compared to mineral N fertilizer application. Data listed in Table (9) reveal that the highest WUE values, i.e. 1.19 and 1.17 kg grains m^{-3} water consumed in 2008/2009 and 2009/2010 seasons, respectively, were detected from irrigating wheat plants at 1.2 C.P.E. Irrigation at 0.8 C.P.E. gave the lowest WUE values, i.e. 1.06 and 1.01 kg grains m^{-3} water consumed in the two successive seasons, respectively. These results are in agreement with those reported by Yousef and Eid (1999).

Table (9): Effect of N fertilizer forms and irrigation scheduling on water use efficiency for wheat crop (WUE, kgm^{-3} water consumed)

Irrig. Trea. / Fert. forms	2008/2009 season				2009/2010 season			
	Irrigation scheduling			Mean	Irrigation scheduling			Mean
	0.8 PEC	1.0 PEC	1.2 PEC		0.8 PEC	1.0 PEC	1.2 PEC	
F_1	0.90	1.07	1.09	1.02	0.85	1.01	1.04	0.97
F_2	1.13	1.18	1.22	1.18	1.07	1.13	1.19	1.13
F_3	1.16	1.24	1.27	1.22	1.12	1.26	1.29	1.22
Mean	1.06	1.16	1.19	1.14	1.01	1.13	1.17	1.10

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العلاقات المائية ومحصول القمح تحت صور مختلفة للتسميد النيتروجيني وجدولة الري

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أقيمت التجربة الحقليه في محطة البحوث الزراعية بطاميه – محافـــة الفيـــوم . خـــلال موسمي ٢٠٠٩/٢٠٠٨ ، ٢٠١٠/٢٠٠٩ لدراسة تأثير الصور المختلفة من التسميد النيتروجينـــي وجدولة الري علي محصول القمح ومكوناته صنف (جيـــزة ١٦٨) وبعـــض العلاقـــات المائيـــة للمحصول، ولتحقيق ذلك تفاعلت ثلاث صورمن التسميد النتيروجيني وهي (F_1) تسميد عضوي (سماد الدواجن)، (F_2) سماد حيوي (بيوجين) + ٣٧,٥كجم ن كسماد نتـــرات امونيـــوم ، (F_3) سماد نيتروجيني معدني (نترات امونيوم ٣٣% ن بمعدل ٧٥ كجم ن/فدان))مع ثلاث معـــاملات لجدولة الري وهي (١) الري عند ٠,٨ ، (٢) الري عند ١,٠ ، (٣) الري عند ١,٢ مـــن البخـــر التراكمي لوعاء البخر القياسي في تصميم القطع المنشقة مرة واحدة في اربعة مكررات .

وفيما يلي أهم النتائج المتحصل عليها:-

١. استخدام الصورة المعدنية للنيتروجين والري عند ١,٢ من بخر الوعاء التراكمي أعطي أعلـــي المتوسطات لعدد السنابل/م٢ وزن ال ١٠٠٠ حبة (جم) ومحصول الحبوب/فدان (٢١٤٩,٢٨ ، ٢٢٧١,٥٠ كجم /فدان) ومحصول القش (٢٦١٩,٦٠ ، ٢٧٧٥,٨٥ كجم/فدان) فـــي الموســـمين المتعاقبين علي التوالي. ولكن طول النبات لم يتأثر معنويا سوي في الموسم الثاني فقط ، وقـــد كانت أقل المتوسطات المتحصل عليها هي عند اشتخدام السماد العضوي والري عند ٠,٨ مـــن بخر الوعاء التراكمي.
٢. كان الاستهلاك المائي الموسمي للمعاملات المختلفة ٣٩,٢٣ ، ٤١,٨٣ سم في ٢٠٠٩/٢٠٠٨ ، ٢٠١٠/٢٠٠٩ علي الترتيب وكانت أعلي المتوسطات (٤٤,١٢ ، ٤٦,٣٦ سم) قد نتجـــت مـــن التسميد المعدني والري عند ١,٢ من بخر الوعاء التراكمي في الموسمين النتعاقبين علي الترتيب ، بينما كانت أقل المتوسطات (٣٥,٦٥ ، ٣٨,٧٢ سم) في الموسمين المتعاقبين علي الترتيب قد نتجت من التسميد العضوي والري عند ٠,٨ من بخر الوعاء التراكمي.
٣. بدأ معدل الاستهلاك المائي اليومي بقيم منخفضة خلال نوفمبر وديسمبر ثم إزداد خـــلال ينـــاير وفبراير ليصل الي اقصي قيمه له خلال مارس ثم عاود الانخفاض مرة اخري خـــلال ابريـــل وحتي الحصاد في مايو في الموسمين، وكانت قيم ثابـــت المحـــصول٠,٥٣ ، ٠,٦١ ، ٠,٧١ ، ٠,٧٩ ، ٠,٩٣ ، ٠,٦١ و ٠,٥٢ (متوسط الموسمين) للشهور نوفمبر ، ديسمبر، يناير ، فبراير، مارس ، ابريل ،مايو علي الترتيب.
٤. كانت أعلي قيم لكفاءة استعمال الماء هي ١,٢٧ ، ١,٢٩ كجم حبوب / م٣ ماء مستهلك قد نتجت من معاملة التسميد المعدني والري عنـــد ١,٢ مـــن وعـــاء البخـــر التراكمـــي فـــي موســـمي ٢٠٠٩/٢٠٠٨ ، ٢٠١٠/٢٠٠٩ علي الترتيب.

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