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EFFECT OF DIFFERENT FORMS OF N- FERTILIZER AND WATER REGIME ON ONION PRODUCTION AND SOME CROP - WATER RELATIONS

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ABSTRACT

A field experiment was conducted at Dar El- Ramad, Fayoum District, Fayoum, Egypt during 2008/2009 and 2009/2010 seasons to study the effect of N fertilizer forms, i.e. F_1: mineral N fertilizer form at the rate of 100 unit N fed^{-1} (as ammonium nitrate 33.0% N), F_2: bio-fertilizer(biogena)+50 unit N/fed, as mineral fertilizer and F_3: organic form as chicken manure and irrigation regime treatments, i.e. $I_{1:}$ irrigation at 40% Available Soil Moisture Depletion (ASMD), $I_{2:}$ irrigation at 60% ASMD and $I_{3:}$ irrigation at 80% ASMD on yield, yield components and some crop-water relations of onion crop (Giza 20 cv.). The split-plot design with four replications was used, where N forms were occupied the main plots while the split ones were allocated to irrigation regimes .

The main obtained results were as follows:

1- Using mineral N form and irrigation at 40% ASMD. gave the highest averages of dry bulbs weight, dry bulbs diameter and dry bulbs yield (17.22 and 16.95 t dry bulbs fed^{-1}) in the two successive seasons. The lowest averages of yield and its components were obtained from using FYM fertilizer form and irrigation at 80% ASMD in both seasons.

2- Seasonal consumptive use (ET_C) averages were 41.18 and 40.45 cm in 2008/2009 and 2009/2010 seasons, respectively. The highest ET_c values, i.e. 45.49 and 44.48 cm were recorded from F_1I_1 interaction ,in 2008/2009 and 2009 /2010 seasons, respectively, whereas the lowest values, i.e. 37.24 and 36.57cm in the two successive seasons were resulted from F_3I_3 interaction.

3- Daily ET_C rates were low during Dec., then increased during Jan. and Feb., to reach its interaction maximum values during March and then declined again at April till harvesting. The values of daily ET_c were decreased by applying organic or bio-fertilizer forms and increased irrigation regime more than 40% ASMD in the two growing season's months. The crop coefficient (K_C) values were 0.45, 0.66, 0.75, 0.94, 0.63 and 0.43 (averages of the two seasons) for Dec., Jan., Feb., Mar., Apr. and May, respectively.

4- The highest water use efficiency values i.e. 9.054 and 8.998 kg dry bulb yield m^{-3} water consumed were obtained from irrigation at 40% ASMD as interacted with N fertilizer in the mineral form in 2008/2009 and 2009/2010 seasons. However, on managing the limited water resources efficiently under the present experiment conditions, it is advisable to irrigate the onion crop at 60% ASMD with mineral N fertilizer form in order to obtain reasonable figures for water productivity and to conserve irrigation water.

Keywords: Onion yield, yield components, N fertilizer forms, irrigation regime, onion crop - water relations.

INTRODUCTION

Onion (*Allium cepa* L.) is one of the most important vegetable crops grown in Egypt, not only for local consumption but also for exportation. Onion production is affected by different factors such as climatic conditions, irrigation management, soil fertility….etc. Nitrogen is an essential element for both growth and productivity of all plants. The interaction between fertilization and irrigation is considered as one of the most important issue affecting onion production. N - fertilizer in mineral forms lead to increase of water consumption and water use efficiency due to the yield increases, Schwartz and Bartolo (1995) and Ardell *et al.* (2008). The beneficial effect of inorganic nitrogen application to give high onion yield and its components previously noted by Mahmoud *et al.* (2000); Tiwori *et al.* (2002); Devi *et al.* (2003); Abdel-Mawgoud *et al.* (2005) and Al-Fraihat (2009). The soil productivity (synonymous with the soil carbon content) could be reduced due to intensive cultivation, so regular addition of organic manure is an important practice in order to improve the soil physiochemical characteristics and consequently the crop performance. Biofertilizer is a substance contains living microorganisms which, when applied to seed, plant surfaces, or soil, colonizes the rhizosphere or the interior of the plant and promotes growth by increasing the supply or availability of primary nutrients to the host plant (Vessey,2003). Biofertilizers are widely accepted as low cost supplements to chemical fertilizers and haven't deleterious effect either on soil health or ambient environment (Bhagyaraj and Suvarna,1999 and Bendegumbal, 2007).

Regarding the effect of irrigation regime, Doorenbos *et al*. (1979) reported that for optimum yield, onion required 350-550mm water. The crop coefficient (K_C) after transplanting is 0.4- 0.6 (15 -20 days), the crop development stage 0.7 – 0.8 (25 – 35 days), the mid – season stage 0.95 – 1.1 (25 – 45 days), the late season stage 0.85 – 0.90 (35 – 45 days) and at harvest 0.75 – 0.85. For high yield, soil water depletion should not exceed 25% of available soil moisture. The crop is most sensitive to water deficit particularly during the period of rapid bulb growth (60 days after transplanting) and frequent light irrigations is required to avoid cracking of the bulbs and forming doubles. A good bulb yield is about 35-45 ha^{-1}, and the water use efficiency is 8-10 kg m^{-3} water consumed. Pelter et al.(2004) found that total onion yield was reduced by soil-water stress imposed at any growth stage but the greatest effect was at the 5-leaf, 7-leaf, and 3- and 7-leaf stages. Soil-water stress caused by withholding irrigation at both the 3- and 7-leaf stages reduced yields by 26%, compared with the control. In connection, Abu-Awwad(1999) stated that increasing applied irrigation water significantly increased evapotranspiration and/or transpiration for onion crop. Furthermore, Kadayifci, et al.(2005) found that high water use for onion was observed with increasing levels of irrigation. The greater the amount of irrigation water applied, the higher the yield obtained. Thus, the highest total yields (24.5 t ha^{-1} with 467 mm and 38.9 t ha^{-1} with 612 mm water applied) were obtained by irrigation until 8 and 7 days before harvest Saha *et al.* (1997), Govila *et al.* (1998), Koriem *et al.* (1999).

The present trials aiming at assessing different irrigation regimes, based on soil monitoring technique, as interacted with N-fertilization in different forms owing to find out the optimum interaction resulting in onion yield potential and improved water use efficiency as well.

MATERIALS AND METHODS

The present investigation was conducted at Dar El- Ramad, Fayoum district, Fayoum Governorate, Egypt, during 2008/2009 and 2009/2010 seasons to study the effect of different N fertilizer forms and irrigation scheduling, based on soil moisture monitoring, treatments and their interaction on yield, yield components and some crop - water relations for onion. Three fertilizer forms, i.e. F_1: mineral N form (as ammonium nitrate 33.0% N) at the rate of 100 unit N fed^{-1} was applied in three equal doses (at planting, 1st and 2nd irrigations), F_2: biofertilizer (biogena)+50 unit N fed^{-1} mineral form and F_3: organic fertilizer, as chicken manure(3.1% N, by weight was applied during field preparation at the rate of $20 m^3 fed^{-1}$). The adopted irrigation regime treatments were irrigating at I_1: 40% Available Soil Moisture Depletion (ASMD), I_2: 60% ASMD and I_3: 80% ASMD. The treatments were assessed in the split-plot design with four replications where N forms were occupied the main plots while the split ones were allocated to irrigation regime treatments. The sub -plot area was 21.0 m^2 (3.0×7.0 m). Calcium super phosphate (15.5% P_2O_5) was added at the rate of 300 kg fed^{-1} during the field preparation. Onion seedlings (Giza 20 cv) were transplanted in hills of 10 cm apart on both sides of the ridges (60 cm width) on December 5th , whereas harvesting was executed on May7th in the two successive seasons. Each experimental plot was isolated from the others by allays 1.5 m in between to avoid the lateral movement of water. Some physical and chemical properties of the experimental soil were determined according to Klute (1986) and Page *et al.* (1982) and are presented in Table 1, and some soil water constants are illustrated in Table 2. The averages of weather factors for Fayoum Governorate during the onion crop growing seasons are recorded in Table 3. Irrigation scheduling treatments started at 2nd irrigation and date of irrigations and irrigation count under different treatments in both seasons are listed in Table 4.

Table 1: Physical and chemical analysis of the experimental site during 2008/ 2009 and 2009/2010 seasons (average of two seasons).

Physical properties				Chemical properties	
Sand%	Silt%	Clay%	Texture classes	Organic matter%	$CaCo_3$%
19.10	33.6	47.30	clayey	1.93	5.22

Chemical analysis														
Soluble cations, meq/L				Soluble anions, meq/L				EC dS m^{-1}	pH In soil paste	CEC meq/ 100 g soil	Exchangeable Cations meq/100 g soil			
Ca^{++}	Mg^{+}	Na^{+}	K^{+}	Cl^{-}	HCO_3^{-}	CO_3^{-}	SO_4^{--}	2.16	7.81	38.32	Ca^{++}	Mg^{++}	K^{+}	Na+
6.35	5.32	9.83	0.17	7.73	2.23	-	11.74				20.79	11.68	4.54	1.68

Table 2: The average values of 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 (gcm^{-3})	Available moisture (%wt/wt)
00-15	45.81	24.36	1.28	21.45
15-30	43.62	23.75	1.31	19.87
30-45	41.01	23.42	1.37	17.59
45-60	40.31	23.37	1.43	16.94

Table 3: The monthly averages of weather 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			
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

At harvesting time, the following data were collected under each sub-plot :-

I. Yield and yield components:

1- Dry bulb weight (g). 2- Dry bulb diameter (cm)

3- Dr**y** bulbs yield (t fed^{-1}).

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

II. Crop - water relationships:

1- Seasonal consumptive use (ET_c).

Crop water consumptive use (ET_c), was determined via soil samples taken from each sub-plot, in 15cm increment system to 60cm depth of soil profile, just before and after 48 hours each irrigation, as well as at harvesting time. The ET_c between each two successive irrigations was calculated according to the following equation:-

Cu (ET_c) = $\{(Q_2-Q_1) / 100\} \times Bd \times D$**(**Israelsen and Hansen, 1962**)…….**where

Cu = Crop water consumptive use (cm).

Q_2= Soil moisture percentage by weight 48 hours after irrigation.

Q_1= Soil moisture percentage by weight just before irrigation.

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

D = Soil layer depth (cm).

4

2. Daily ET_C rate (mm/day).

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

3. Reference evapotranspiration (ET_0)

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

4. 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}) and

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

5-Water use efficiency (WUE).

The water use efficiency as kg onion bulb yield m^{-3} water consumed was calculated for different treatments as the method described by Vites (1965):

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

RESULTS AND DISCUSSION

Yield and yield components:

Data in Table 5 reveal that N fertilizer forms significantly affected onion yield and it's components in both seasons. Mineral N fertilizer gave the highest averages of bulb weight, bulb diameter and dry bulb yield/fed in the two seasons. Bio-fertilizer + 50 unit N fed^{-1} as Amm. Nitrate significantly decreased bulb weight, bulb diameter and dry bulb yield in 2008/2009 season by 8.75%, 5.81% and 6.57%, respectively, and in 2009/2010 season by 6.41%, 6.62% and 3.32%, respectively, as compared with mineral N fertilizer. Moreover, organic N fertilizer (chicken manure) significantly reduced the bulb weight, bulb diameter and dry bulb yield fed^{-1} in 2008/2009 season by 19.80%, 12.82% and 11.08%, respectively, and by 18.37%, 11.45% and 12.32%, respectively, in 2009/2010. 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 Mahmoud *et al.* (2000), Devi *et al.* (2003), Abdel-Mawgoud *et al.* (2005) and Al-Fraihat (2009).

Regarding the effect of irrigation regime treatments, data in Table 5 show that onion yield and its components were significantly affected by irrigation treatments in both seasons. Irrigation onion at 40% ASMD gave the highest averages of yield and its components, whereas, irrigation at 80% ASMD gave the lowest ones in both seasons. Increasing the available soil moisture depletion (ASMD) from 40 to 80 % significantly decrease bulb weight, bulb diameter and dry bulb yield in first season by 23.4%, 21.93 and 17.63% and by 21.48%, 23.17% and 20.38%, respectively in the second season. In this sense, Pelter et al.(2004) found that total onion yield was reduced by soil-water stress imposed at any growth stage but the greatest effect was at the 5-leaf, 7-leaf, and 3- and 7-leaf stages. Soil-water stress caused by withholding irrigation at both the 3- and 7-leaf stages reduced yields by 26%, compared with the control. It could be concluded that increasing the level of available soil moisture depletion in root zone of onion plants caused significant reduction in the bulb onion yield and yield components due to reducing water and nutrients absorption which in turn reduced photosynthesis, cell division and dry matter accumulation in plant organs. The obtained results are in line with those reported by Doorenbos *et al*. (1997), Saha *et al.* (1997), Gaviola *et al.* (1998), Koriem *et al.* (1999).

Data in Table 5 indicate that yield and its components were significantly affected by the interaction of N fertilizer forms and irrigation regime treatments except dry bulb diameter in first season. The highest averages of bulb weight, bulb diameter and dry bulb yield fed^{-1} were detected from mineral N fertilizer as interacted with irrigation at 40% ASMD in both seasons. On the other hand, the lowest averages of yield and its components were resulted from organic manure (chicken manure) as interacted with irrigation at 80% ASMD in both seasons.

Table 5: Effect of N fertilizer forms and irrigation regime treatments on yield, dry bulb weight and dry bulb diameter of onion crop2008/2009 and 2008/2010 seasons.

Fertilizer Form*	Irrigation Regime	2008/2009 season			2008/2010 season		
		Dry bulb weight (g)	Dry bulb Diameter (cm)	Dry bulbs Yield (t fed^{-1})	Dry bulb weight (g)	Dry bulb Diameter (cm)	Dry bulbs Yield (t fed^{-1})
F1	40%	108.4	6.52	17.22	94.61	6.31	16.95
	60%	93.94	5.92	16.07	87.36	5.6	15.11
	80%	83.15	5.10	14.62	77.03	4.87	13.95
Mean		95.16	5.85	15.97	86.33	5.59	15.34
F2	40%	97.73	6.10	16.25	91.01	5.81	16.71
	60%	88.62	5.63	15.11	82.42	5.36	14.83
	80%	74.15	4.80	13.39	68.96	4.50	12.94
Mean		86.83	5.51	14.29	80.80	5.22	14.83
F3	40%	86.93	5.70	15.87	79.89	5.5	15.07
	60%	74.85	5.21	14.09	69.05	5.2	13.38
	80%	67.17	4.40	12.65	62.47	4.16	11.89
Mean		76.32	5.10	14.20	70.74	4.95	13.45
Irrigation mean							
40%		97.69	6.11	16.45	88.50	5.87	16.24
60%		85.80	5.59	15.09	79.61	5.39	14.44
80%		74.82	4.77	13.55	69.49	4.51	12.93
LSD, 05							
F		4.12	0.32	0.16	5.60	0.37	0.24
Irrigation regime		2.94	0.15	0.21	5.41	0.12	0.14
F x Irrigation regime		2.85	N.S	0.37	4.11	0.20	0.24

***F1, F2 and F3 referred to the treatments of mineral, bio and organic fertilizers, respectively**

Onion crop-water relations:

Seasonal consumptive use (ET_C)

Results in Table 6 indicate that seasonal consumptive use or evapotranspiration (ET_C) of onion crop, as a function of N fertilizer forms and irrigation regime treatments were, 41.18 and 40.45 cm in 2008/2009 and

2009/2010 seasons, respectively. The difference may be due to the variation in weather factors of the two seasons (Table, 2) and higher onion yield in 2008/2009 season. Mineral N treatment gave the highest values of onion ET, i.e. 38.71 and 38.05 cm in two successive seasons. Bio-fertilizer + 50 unit N, as Amm Nitrate fertilizer or organic fertilizer (chicken manure) decreased seasonal ET_C in 2008/2009 season by 6.24 and 11.56% and by 6.71 and 11.72% in 2009/2010 season, respectively, comparable with mineral N treatment . It is obvious that biofertilizer or organic N fertilizer forms resulted in lower seasonal consumptive use which could be referred to the lower performance of onion crop under such fertilizer forms in the present research trial.

Regarding the effect of irrigation regime treatments, data in Table 6 show that onion irrigating at 40% ASMD produced the highest values of ET_C reached 42.70 and 41.92 cm in 2008/2009 and 2009/2010 seasons, respectively. The lowest ET_C values i.e. 39.69 and 39.09 cm were resulted from irrigating at 80% ASMD in the two successive seasons. Moreover, irrigation at 60% ASMD deceased ET_C by 3.65 and 3.75%, in 2008/2009 and 2009/2010 seasons, respectively, comparable with irrigating at 40% ASMD. It could be concluded that increasing the available soil moisture in the root zone of onion plants, under irrigation at 40% ASMD treatment, caused increases in ET_C throughout the entire growing 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. In connection, Abu-Awwad(1999) stated that increasing applied irrigation water significantly increased evapotranspiration and/or transpiration for onion crop. Furthermore, Kadayifci, et al.(2005) found that high water use for onion was observed with increasing levels of irrigation. Under water stress, irrigation at 60% or 80%, the transpiration from plants may decrease as a result of poor vegetative growth and less evaporation due to dry soil surface. These results are in accordance with those reported by Doorenbos *et al.* (1979), Saha *et al.* (1997), Govila *et al.* (1998), Koriem *et al.* (1999).

Data in Table 6 indicate that mineral N fertilizer and irrigation at 40% ASMD interaction gave the highest values of ET_C which comprised 45.49 and 44.48 cm in the first and second seasons, respectively. Nevertheless, the lowest ET_C values, i.e. 37.24 and 36.57 cm in the two successive detected under organic fertilizer (chicken manure) as interacted with irrigation at 80% ASMD.

Table 6: Effect of N fertilizer forms and irrigation regime on seasonal consumptive use of onion crop (ET_C) in cm.

Fertilizer Form*	2008/2009 season				2009/2010 season			
	Irrigation Regime			Mean	Irrigation Regime			Mean
	40% ASMD	60% ASMD	80% ASMD		40% ASMD	60% ASMD	80% ASMD	
F_1	45.49	43.49	42.34	**43.77**	44.48	42.85	41.98	**43.10**
F_2	42.46	41.18	39.48	**41.04**	41.73	40.17	38.72	**40.21**
F_3	40.15	38.75	37.24	**38.71**	39.56	38.02	36.57	**38.05**
Mean	**42.70**	**41.14**	**39.69**	**41.18**	**41.92**	**40.35**	**39.09**	**40.45**

***F1, F2 and F3 referred to the treatments of mineral, bio and organic fertilizers, respectively**

Daily ET_C (mm day^{-1})

Results in Table 7 show that the daily ET_C rates, as influenced by different treatments tested in both seasons, started with low values during Dec and then increased again during Jan. and Feb. to reach its maximum values on March. Thereafter, it tended to decrease 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 and lower evaporative demands (lower values of temperature and solar radiation). Thereafter, as the plant cover and temperature increased both evaporation and transpiration tended to increase and reached maximum values during (March). At maturity stage ET_C rate decreased again during May (harvesting). The results in Table 7 indicate that the highest values of $ET_{C,}$ during the two growing seasons, were reported during (Dec. – May) under mineral N fertilizer treatment. On the other hand, under chicken manure the lowest values of daily ET_C rates during growing seasons were recorded and such trend was observed in 2008/2009 and 2009/2010 seasons. These findings could be attributed to mineral N fertilizer which exhibited higher onion yield values, comparable with FYM treatment.

Table 7: Effect of N fertilizer form and irrigation regime treatments and their interaction on water consumptive use (mm day^{-1}) in 2008/2009 and 2009/2010 seasons.

N-Fertilizer form*	Irrigation regime	2008/2009 season						2009/2010 season					
		Dec	Jan.	Feb.	Mar.	Apr	May	Dec.	Jan.	Feb.	Mar.	Apr	May
F_1	40% ASMD	0.94	1.63	2.86	4.90	4.00	3.65	0.92	1.66	2.82	4.80	3.92	3.60
	60% ASMD	0.94	1.63	2.75	4.66	3.65	3.60	0.92	1.61	2.72	4.61	3.75	3.45
	80% ASMD	0.94	1.61	2.68	4.51	3.45	3.45	0.92	1.56	2.65	4.56	3.64	3.38
	Mean	0.94	1.62	2.76	4.69	3.70	3.57	0.92	1.61	2.73	4.66	3.70	3.48
F_2	40% ASMD	0.94	1.59	2.68	4.61	3.30	3.30	0.92	1.56	2.65	4.51	3.64	3.23
	60% ASMD	0.94	1.54	2.68	4.51	3.23	3.13	0.92	1.50	2.55	4.37	3.47	3.08
	80% ASMD	0.92	1.47	2.44	4.37	3.08	3.08	0.92	1.43	2.41	4.28	3.30	3.00
	Mean	0.93	1.53	2.60	4.50	3.20	3.17	0.92	1.50	2.54	4.39	3.47	3.10
F_3	40% ASMD	0.90	1.50	2.55	4.42	3.20	3.15	0.88	1.52	2.51	4.32	3.36	3.08
	60% ASMD	0.90	1.50	2.44	4.28	3.15	3.08	0.88	1.38	2.41	4.18	3.25	3.04
	80% ASMD	0.90	1.33	2.27	4.09	3.09	3.00	0.86	1.29	2.24	4.09	3.14	3.00
	Mean	0.90	1.44	2.42	4.26	3.15	3.08	0.87	1.40	2.39	4.20	3.25	3.04
Irrigation mean													
40% ASMD		0.93	1.57	2.70	4.64	3.50	3.37	0.91	1.58	2.66	4.54	3.64	3.30
60% ASMD		0.93	1.56	2.62	4.48	3.34	3.27	0.91	1.50	2.56	4.39	3.49	3.19
80% ASMD		0.91	1.41	2.39	4.23	3.16	3.11	0.88	1.37	2.36	4.22	3.27	3.08
Over Mean		0.92	1.47	2.50	4.36	3.26	3.19	0.89	1.44	2.46	4.32	3.39	3.14

*** F1, F2 and F3 referred to the treatments of mineral, bio and organic fertilizers, respectively**

Data in Table 7 show that the daily ET_C rates of onion during the growing season months (Dec. – May) of both seasons, were increased by irrigation at 40% ASMD and the same trend was observed either with irrigation at 60% or 80% ASMD. It is obvious that increasing the available moisture in onion root zone (frequent irrigation i.e. more irrigation events) resulted in increasing the ET_C rate during the entire growing season. These results are in the same line of those reported by Doorenbos *et al.* (1979), Saha *et al.* (1997), Gaviola *et al.* (1998) and Koriem *et al.* (1999).

Reference evapotranspiration (ET_0)

Reference evapotranspiration rate (ET_0, mm day^{--1}) during 2008/2009 and 2009/2010 growing seasons was estimated according to FAO Penman- Monteith method via the meteorological data of Fayoum Governorate , Table 8. The data indicated that the ET_0 rate values were decreased during Dec. and Jan. months. Thereafter, ET_0 increased from Feb. till May. These results are attributed to the variation in weather factors from one month to another. Allen *et al.* (1998) reported that the reference ET values depend mainly on the prevailing evaporative power i.e. air temperature, solar radiation, air relative humidity and wind speed.

Crop coefficient (K_C)

The crop coefficient (K_C) is a function of both Etc and ET_0 values. The crop cover percentage affects ETc and consequently Kc values, Table 7. Results in Table 8 show that the over all mean K_C value of the adopted treatments, started with lower values (0.45 and 0.44), after transplanting, during Dec. and then increased during Jan. (0.66 and 0.65) and Feb. (0.75 and 0.74), as the vegetative growth increased. The K_C values reached its maximum values(0.94 and 0.93) as the percentage of crop cover increased during March and then tended to decrease again(0.64 and 0.63) during Apr. and reached minimum values on May (0.44 and 0.43) at harvesting.

Data in Table 8 reveal that mineral N fertilizer, comparable with bio-fertilizer+50 unit N fed^{-1}, as mineral or FYM, exhibited the highest K_C values during the entire growing season. Increasing the irrigation events (irrigating at 40% ASMD) seemed to increase the K_C values entire the growing season, whereas the lowest K_C values were observed under irrigation at 80% ASMD and such findings were true in both seasons. The K_C values of onion, as a function of different treatments were 0.45, 0.66, 0.75, 0.94, 0.63 and 0.43 for December., January, February, March, April. and May, respectively, (average of the two seasons). Such findings are in the same line of those reported by Doorenbos *et al.* (1979), Saha *et al.* (1997), Gaviola *et al.* (1998), Koriem *et al.* (1999).

Table 8: Effect of N fertilizer forms and irrigation regime treatments on crop coefficient (K_C) of onion crop in 2008/2009 and 2009/2010 seasons

N-Fertilizer Form*	Irrigation regime	2008/2009 season						2009/2010 season					
		Dec.	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Dec.**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**
Reference ET_0		2.6	2.7	3.1	3.7	5.6	5.9	2.4	2.5	3.4	4.3	5.6	6.3
F_1	40% ASMD	0.46	0.73	0.83	1.03	0.71	0.49	0.45	0.72	0.82	1.01	0.70	0.48
	60% ASMD	0.46	0.71	0.80	0.98	0.68	0.48	0.45	0.70	0.79	0.97	0.67	0.46
	80% ASMD	0.46	0.70	0.78	0.95	0.66	0.46	0.45	0.68	0.77	0.96	0.65	0.45
Mean		0.46	0.71	0.80	0.99	0.68	0.48	0.45	0.70	0.79	0.98	0.67	0.46
F_2	40% ASMD	0.46	0.69	0.78	0.97	0.66	0.44	0.45	0.68	0.77	0.95	0.65	0.43
	60% ASMD	0.46	0.67	0.75	0.95	0.63	0.43	0.45	0.65	0.74	0.92	0.62	0.41
	80% ASMD	0.45	0.64	0.71	0.92	0.60	0.41	0.45	0.62	0.70	0.90	0.59	0.40
Mean		0.46	0.67	0.75	0.95	0.63	0.43	0.45	0.65	0.74	0.92	0.62	0.41
F_3	40% ASMD	0.44	0.65	0.74	0.93	0.61	0.42	0.43	0.66	0.73	0.91	0.60	0.41
	60% ASMD	0.44	0.61	0.71	0.90	0.59	0.41	0.43	0.60	0.70	0.88	0.58	0.40
	80% ASMD	0.44	0.58	0.66	0.86	0.58	0.40	0.42	0.56	0.65	0.86	0.56	0.40
Mean		0.44	0.61	0.70	0.90	0.59	0.41	0.43	0.61	0.69	0.88	0.58	0.40
Irrigation mean													
40% ASMD		0.45	0.69	0.78	0.98	0.66	0.45	0.44	0.69	0.77	0.96	0.65	0.44
60% ASMD		0.45	0.66	0.75	0.94	0.63	0.44	0.44	0.65	0.74	0.92	0.62	0.42
80% ASMD		0.45	0.64	0.72	0.91	0.61	0.42	0.44	0.62	0.71	0.91	0.60	0.42
Over all mean		0.45	0.66	0.75	0.94	0.64	0.44	0.44	0.65	0.74	0.93	0.62	0.43

*** F1, F2 and F3 referred to the treatments of mineral, bio and organic fertilizers, respectively**

Water Use Efficiency (WUE)

The results in Table 9 show that WUE average values, as function of the adopted treatments, were 7.930 and 7.930 kg dry bulbs m^{-3} water consumed in 2008/2009 and 2009/2010 seasons, respectively. The highest water use efficiency values e.g.8.691 and 8.776 kg dry bulbs m^{-3} water consumed were obtained under mineral N fertilizer in 2008/2009 and 2009/2010 seasons, respectively. On the other hand, the lowest WUE values i.e. 7.038 and 6.914 kg dry onion bulbs m^{-3} water consumed in 2008/2009 and 2009/2010 seasons, respectively, were obtained under chicken manure form. Data in Table 9 reveal that the highest WUE values i.e. 8.452 and 8.354 kg dry bulbs m^{-3} water consumed in 2008/2009 and 2009/2010 seasons, respectively, were detected from irrigating onion plants at 40% ASMD. Nevertheless, irrigation at 80% ASMD gave the lowest WUE values which comprised 7.394 and 7.490 kg dry bulbs m^{-3} water consumed in the two successive seasons, respectively. These results are in agreement with those reported by Doorenbos *et al.* (1979), Saha *et al.* (1997), Gaviola *et al.* (1998), Koriem *et al.* (1999).

Table 9: Effect of N fertilizer forms and irrigation regime on water use efficiency (kg dry bulbs m^{-3} water consumed) of onion crop

fertilizer form*	2008/2009 season				2009/2010 season			
	irrigation regime			Mean	irrigation regime			Mean
	40% ASMD	60% ASMD	80% ASMD		40% ASMD	60% ASMD	80% ASMD	
F_1	9.054	8.798	8.221	8.691	8.998	8.830	8.500	8.776
F_2	8.551	8.159	7.473	8.061	8.548	8.277	7.471	8.099
F_3	7.750	6.876	6.489	7.038	7.517	6.727	6.498	6.914
Mean	8.452	7.944	7.394	7.930	8.354	7.945	7.490	7.930

***F1, F2 and F3 referred to the treatments of mineral, bio and organic fertilizers, respectively**

On conclusion ,data reveal that irrigating onion crop at 60% ASMD resulted in lower WUE values comprised 6.10 and 4.89% less than those under irrigating at 40% ASMD, respectively, in 2008/2009 and 2009/2010 seasons. So, on managing the limited irrigation water resources efficiently, its advisable to irrigate onion crop at 60% ASMD in order to achieve reasonable water productivity value and to conserve the irrigation water as well.

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تأثير الصور المختلفة من التسميد النيتروجيني والرطوبة الأرضية علي محصول البصل وبعض العلاقات المائية

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أقيمت التجربة الحقلية في منطقة دار الرماد –بمركز الفيوم – محافظة الفيوم . خلال موسمي 2009/2008 ، 2010/2009 لدراسة تأثير الصور المختلفة من التسميد النيتروجيني وجدولة الري علي محصول البصل ومكوناته صنف (جيزة 20) وبعض العلاقات المائية للمحصول، ولتحقيق ذلك تفاعلت ثلاث صور من التسميد النيتروجيني وهي (F_1) سماد نيتروجيني معدني 100 وحدة ن (نترات أمونيوم 33% ن)، (F_2) سماد حيوي (بيوجين) + 50 وحدة ن سماد معدني ، (F_3) تسميد عضوي (سماد الدواجن ,نيتروجين 3.1%) مع ثلاث معاملات لجدولة الري وهي (1) الري عند 40% من استنزاف الرطوبة الأرضية ، (2) الري عند 60% من استنزاف الرطوبة الأرضية ، (3) الري عند 80% من استنزاف الرطوبة الأرضية في تصميم القطع المنشقة مرة واحدة في أربعة مكررات .

وفيما يلي أهم النتائج المتحصل عليها:-

1. استخدام الصورة المعدنية للنيتروجين والري عند 40% من استنزاف الرطوبة الأرضية أعطي أعلي المتوسطات لوزن البصلة وقطر البصلة ووزن المحصول من البصل (17,22 ، 16,95 طن /فدان) في الموسمين المتعاقبين علي التوالي. ، وقد كانت أقل المتوسطات المتحصل عليها هي عند استخدام السماد العضوي والري عند 80% من استنزاف الرطوبة الأرضية.
2. كان الاستهلاك المائي الموسمي للمعاملات المختلفة 41,18 ، 40,45 سم في 2009/2008 ، 2010/2009 علي الترتيب وكانت أعلي المتوسطات (45,49 ، 44,48 سم) قد نتجت من التسميد المعدني والري عند 40% من استنزاف الرطوبة الأرضية في الموسمين المتعاقبين علي الترتيب ، بينما كانت أقل المتوسطات (37,24 ، 36,57 سم) في الموسمين المتعاقبين علي الترتيب قد نتجت من التسميد العضوي والري عند 80% من استنزاف الرطوبة الأرضية.
3. بدأ معدل الاستهلاك المائي اليومي بقيم منخفضة خلال ديسمبر ثم إزداد خلال يناير وفبراير ليصل إلي أقصي قيمه له خلال مارس ثم عاود الانخفاض مرة أخري خلال ابريل وحتى الحصاد في مايو في الموسمين، وكانت قيم ثابت المحصول0,45 ، 0,66، 0,75 ، 0,94 ، 0,63 و 0,43 (متوسط الموسمين) للشهور ديسمبر، يناير ، فبراير ، مارس ، ابريل ،مايو علي الترتيب.
4. كانت أعلي قيم لكفاءة استعمال الماء هي 9,054 ، 8,998 كجم بصل جاف / م^3 ماء مستهلك قد نتجت من تفاعل التسميد المعدني والري عند 40% من استنزاف الرطوبة الأرضية في 2009/2008 ، 2010/2009 علي الترتيب.

قام بتحكيم البحث

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Table 4: Dates and irrigation number of onion as affected by N fertilizer forms* and irrigation regime treatments in 2008/2009 and 2009/2010 seasons

Irrigation event*	2008/2009 season									2009/2010 season								
	F_1			F_2			F_3			F_1			F_2			F_3		
	Available soil moisture depletion			Available soil moisture depletion			Available soil moisture depletion			Available soil moisture depletion			Available soil moisture depletion			Available soil moisture depletion		
	40%	60%	80%	40%	60%	80%	40%	60%	80%	40%	60%	80%	40%	60%	80%	40%	60%	80%
	Date			Date			Date			Date			Date			Date		
Transplanting	6/12	6/12	6/12	6/12	6/12	6/12	6/12	6/12	6/12	6/12	6/12	6/12	6/12	6/12	6/12	6/12	6/12	6/12
1st irrigation	27/12	27/12	27/12	27/12	27/12	27/12	27/12	27/12	27/12	26/12	26/12	26/12	26/12	26/12	26/12	26/12	26/12	26/12
2nd	13/1	20/1	26/1	13/1	20/1	26/1	13/1	20/1	26/1	13/1	21/1	26/1	13/1	21/1	26/1	13/1	21/1	26/1
3rd	1/2	13/2	25/2	1/2	13/2	25/2	1/2	13/2	25/2	2/2	14/2	25/2	2/2	14/2	25/2	2/2	14/2	25/2
4th	19/2	9/3	27/3	19/2	9/3	27/3	19/2	9/3	27/3	21/2	10/3	27/3	21/2	10/3	27/3	21/2	10/3	27/3
5th	10/3	3/4	26/4	10/3	3/4	26/4	10/3	3/4	26/4	13/3	4/4	26/4	13/3	4/4	26/4	13/3	4/4	26/4
6th	28/3	25/4	-	28/3	25/4	-	28/3	25/4	-	29/3	26/4	-	29/3	26/4	-	29/3	26/4	-
7th	15/4	-	-	15/4	-	-	15/4	-	-	164	-	-	164	-	-	164	-	-
Harvesting	7/5	7/5	7/5	7/5	7/5	7/5	7/5	7/5	7/5	7/5	7/5	7/5	7/5	7/5	7/5	7/5	7/5	7/5
Irrigation count	8	7	6	8	7	6	8	7	6	8	7	6	8	7	6	8	7	6

*** F1, F2 and F3 referred to the treatments of mineral, bio and organic fertilizers, respectively**