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إدراة المياه لمحصول الذرة الشامية تحت التسميد بالامونيا الغازية

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الملخص العربي

أقيمت تجربتان حقليتان بمزرعة محطة البحوث الزراعية بطامية – محافظة الفيوم – خلال موسمي الزراعة صيف ٢٠٠٩ ، ٢٠١٠ لدراسة تأثير التسميد بالامونيا الغازية وجدولة الري علي بعض قياسات النمو ومحصول الذرة الشامية ومكوناته (صنف هجين ثلاثي ٣١٠) وبعض العلاقات المائية للمحصول . ولتحقيق ذلك تفاعلت ثلاثة معدلات لاضافة الامونيا الغازية وهي (٩٠ ، ١١٠ ، ١٣٠ كجم ن / فدان) مع ثلاث معاملات لجدولة الري وهي (١) الري عند ٠.٨ ، (٢) الري عند ١.٠ ، (٣) الري عند ١.٢ من البخر التراكمي لوعاء البخر القياسي في تصميم القطع المنشقة مرة واحدة في اربعة مكررات . وفيما يلي ملخص لأهم النتائج المتحصل عليها:–

١. تأثرت قياسات النمو المدروسه و محصول الفدان ومكونات المحصول معنويا بمواعيد الزراعة وكذلك بمعاملات جدولة الري وقد أدي إضافة الامونيا الغازية بمعدل ١٣٠ كجم ن / فدان والري عند ١,٢ من بخر الوعاء التراكمي للحصول علي أعلي متوسطات لارتفاع النبات وعدد الاوراق علي النبات وقطر الساق وطول وقطر الكوز ووزن الحبوب/نبات ووزن ال١٠٠ حبه في كلا الموسمين ، بينما ادي اضافة ٩٠ كجم ن/فدان والري عند ٠,٨ من بخر الوعاء التراكمي للحصول علي اقل المتوسطات لقياسات النمو ومكونات المحصول.
٢. نتج أعلي متوسط محصول حبوب(٢٨٤١,٥٥ ، ٣٠٣٨,١٣ كجم حبوب/فدان) من التسميد ب ١٣٠ كجم ن/فدان والري عند ١,٢ من بخر الوعاء التراكمي، وفي المقابل ادي التسميد ب ٩٠ كجم ن/فدان والري عند ٠,٨ من بخر الوعاء التراكمي للحصول علي اقل المتوسطات وكانت ١٦٦٣,٨٧ ، ١٩١٥,١٣ كجم حبوب/فدان في موسمي ٢٠٠٩ ، ٢٠١٠ علي الترتيب.

٣. كان متوسط الاستهلاك المائي الموسمي للتفاعل بين المعاملات هو ٥٩,٤١ ، ٦١,٢١ سم في موسمي ٢٠٠٩ ،٢٠١٠ علي الترتيب وكانت أعلي قيم للاستهلاك لمائي الموسمي وهي ٦٣,١١ ، ٦٤,٧٣ سم في ٢٠٠٩ ،٢٠١٠ علي الترتيب قد نتجت من التسميد ب ١٣٠ كجم ن/فدان والري عند ١,٢ بخر تراكمي للوعاء وكانت أقل قيم للاستهلاك المائي الموسمي وهي ٥٥,٨٤ ، ٥٨,٤٧ سم قد نتجت من التسميد ب ٩٠ كجم ن/فدان والري عند ٠,٨ بخر تراكمي للوعاء في الموسمين المتعاقبين.

٤. كان معدل الاستهلاك المائي اليومي للمحصول منخفضاً خلال يونية ثم إزداد خلال يوليو ليصل الي قمة الاستهلاك خلال أغسطس ثم انخفض خلال سبتمبر في كلا الموسمين ، وكان ثابت المحصول للمعاملة التي اعطت أعلي محصول حبوب (كمتوسط للموسمين) هو ٠,٤٣ ، ٠,٧١ ، ٠,٩٥ ،٠,٧٠ خلال يونيو ويوليو وأغسطس وسبتمبر علي الترتيب.

٥. نتجت أعلي كفاءة استهلاك للماء وهي ١,٠٧٢ ، ١,١١٧ كجم حبوب/ م٣ ماء مستهلك في ٢٠٠٩ ،٢٠١٠ علي الترتيب من التسميد ب ١٣٠ كجم ن/فدان والري عند ١,٢ بخر تراكمي للوعاء في الموسمين المتعاقبين.

WATER MANAGEMENT OF MAIZE CROP UNDER LIQUID AMMONIA GAS FERTILIZATION

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ABSTRACT: ***Two field experiments were carried out at Fayoum Agric. Res. Station (Tameia) during 2009 and 2010 summer seasons. The study aims to find the effects of three N- rates(as liquid ammonia gas) i.e. F_1:90 kg N /fed, F_2: 110 kg N /fed and F_3: 130 kg N /fed as interacted with three irrigation scheduling treatments, according to the cumulative pan evaporation (C.P.E) e.g. irrigation at (I_1):0.8, (I_2):1.0 and (I_3): 1.2 C.P.E. coefficients on some growth attributes, yield components, grain yield and some crop - water relations of maize hybrid (TWC 310). The split- plot design with four replications was used where the main plots were occupied with N fertilization rates while the split ones were allocated for scheduling irrigation treatments. The main obtained results were as follows:***

1. ***Growth, grain yield and yield components parameters were significantly affected due to both N-rates and irrigation scheduling treatments in both seasons. N- rate of 130 kg N/fed (F_3) as interacted with irrigation at 1.2 C.P.E (I_3) gave the highest averages of plant height, N° of leaves/plant, stem diameter, ear length, ear diameter, grain weight/plant and 100-grain weight in both seasons. Nevertheless, interaction of 90 kg N /fed rate (F_1) with irrigation at 0.8 C.P.E (I_1) gave the lowest figures of both growth parameters and yield components averages in both seasons.***
2. ***The highest grain yield, i.e. 2841.55 and 3038.13 kg grains/fed were detected from F_3I_3 interaction in 2009 and 2010 seasons, respectively. On the contrary, interaction of 90 kg N /fed (F_1) and irrigation at 0.8 C.P.E (I_1) gave the lowest grain yield which amounted to 1663.87 and 1915.13 kg grains/fed in 2009 and 2010 seasons, respectively.***
3. ***Seasonal water consumptive use (ET_C) reached 59.41 and 61.21 cm, as overall average, in 2009 and 2010 seasons, respectively. The highest ET_C values i.e. 63.11 and 64.73 cm were recorded from F_3I_3 interaction whereas the lowest values i.e. 55.84 and 58.47 cm was resulted from F_1I_1 interaction in 2009 and 2010 seasons, respectively.***
4. ***The daily ET_C rates were low during June and tended to increase during July to reach its peak during August and then declined during September in both seasons. The crop coefficient (K_C) values, for high grain yield, were 0.43, 0.71, 0.95, and 0.70 for June, July, August and September, respectively(average of two seasons)***
5. ***The highest water use efficiency amounted to 1.072 and 1.117 kg grain/m^3 water consumed due to F_3I_3 interaction in 2009 and 2010 seasons, respectively.***

Key words: ***maize yield, growth attributes, yield components, liquid ammonia gas fertilization, irrigation scheduling, maize crop - water relations.***

INTRODUCTION

Maize (*Zea Mays L.*) is one of the most important summer cereal crops grown in Egypt. Maize grain is used for both human and poultry consumption. Therefore, increasing maize production is very important concern. Adequate supply of irrigation water and optimum N fertilizer rate are two main factors affecting directly the growth and productivity of maize plants. Uhart and Rade (1995) pointed out that N deficiency reduce maize growth and, consequently, biomass yield. El- Bana and Gomaa (2000) and El-Douby *et al.* (2001) revealed that a significant increases in stem diameter, leaf area, ear length, ear diameter, 100-grain weight, grain yield/plant and grain yield. In this sense, Siam *et al.* (2008) mentioned that the increasing N level significantly increased plant height, fresh and dry weight, ear weight, 100-grain weight and grain yield.

Concerning the effect of nitrogen fertilizer on crop - water relations, Ainer (1983), Sadik *et al.* (1995) and Elvio and Michele(2008) found that the gradual increase in nitrogen fertilization rate gradually increased water consumptive use for maize crop.

Regarding the effect of irrigation on maize crop water relations, Doorenbos *et al.* (1979) reported that water requirement of maize for maximum production varied between 430-490 mm per season depending on climate and season length. Musck and duesk (1980) reported that water deficit affected maize yield and irrigation requirements was 400mm for grain yield of 9.52-10.85 ton/ha and water use efficiency(WUE) ranged from 1.25 to 1.45 kg/m^3. EL- Noemany *et al.* 1990 , Ibrahim *et al.* 1992 and Atta- Allah 1996 revealed that extending the irrigation interval for maize crop reduced vegetative growth, yield components and grain yield. Moreover, Sharaan *et al.* (2002) concluded that increasing irrigation interval from 10 to 20 days decreased significantly maize grain yield from 3641.9 to 2868.9 kg/fed, seasonal ET_C from 59.9 to 55.3 cm, daily ET_C from 5.25 to 4.86 mm/day and WUE from 1.445 to 1.340 kg/m^3. The crop coefficient (K_C) values were 0.74, 0.913, 1.110 and 0.270 for June, July, August and September, respectively. El-Tantawy *et al.* (2007) showed that maize growth and yield attributes were increased with increasing the ratio of irrigation water to C.P.E. The highest ET_C and WUE were resulted from irrigation at 1.2 C.P.E. Abdel-Maksoud *et al.* (2008) found that increasing irrigation interval from 7 to 14 or 21 days significantly reduced all yield components, grain yield, ET_C and daily ET_C for maize crop. Irrigation every 14 days gave the highest WUE values (0.972 kg grains/m^3 water consumed). The K_C values were 0.53, 0.74, 0.99, 0.71 and 0.62 for June, July, August, September and October, respectively.

The present trial aiming at managing the irrigation water in efficient manner using the daily records of pan evaporation, under different N-rate in liquid ammonia form, in order to maximize maize yield, conserve water and enhance water use efficiency.

MATERIALS AND METHODS

Two field experiments were conducted at the farm of Tameia Agric. Res. Station, Fayoum Governorate during the summer seasons of 2009 and 2010 to study the effect of N- rates(liquid ammonia gas, 82%N) and irrigation scheduling treatments on maize crop and crop water relations. To achieve these targets three rates of N as 90 kg N/fed ($F_{1)}$, 110 kg N/fed (F_2) and 130 kg N/fed (F_3) 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. in the split-plot design with four replications. The effect of the adopted treatments and interaction on growth parameter, grain yield and yield components as well as some crop - water relations were studied. Calcium super phosphate (15.5% P_2O_5) at the rate of 150 Kg was added during field preparation. Nitrogen fertilization was soil-injected as liquid ammonia gas 7 days before sowing. Maize hybrid (TWC, 310) seeds were sown at seeding rate of 15 Kg grains/fed on June 1st in hills 25cm apart system in the two seasons of study. Irrigation scheduling treatments were applied at the 2nd irrigation. 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 find out the proper coefficient resulted in maize yield potential and improve water use efficiency as well. So irrigation was 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

Grain Ears were harvested on Sep. 23, 2009 and Sep 25 , 2010 . Some soil physical and chemical properties of the experimental plots were determined according to Klute (1986) and Page *et al.* (1982) and presented in Table (1). The monthly averages of climatic factors for Fayoum region during the two growing seasons are shown in Table (2). Some soil moisture constants and bulk density of the experimental field (mean of the two seasons) are listed in Table (3).

Table (1): Some soil physical and chemical properties of the experimental field (average of 2009 and 2010 seasons)

Physical properties				Chemical properties	
sand%	Silt%	Clay%	Texture classes	Organic matter%	$CaCo_3$%

38.00	21.2	40.8	Clay loam	1.68	5.18

Chemical analysis															
Soluble cations meq/L				Soluble anions meq/L				EC dS/m	pH 1:2.5	CEC meq/ 100 g soil	Exchangeable Cations meq/100 g soil			
Ca^{++}	Mg^{+}	Na^{+}	K^{+}	Cl^{-}	HCO_3^{-}	CO_3^{--}	SO_4^{--}				Ca^{++}	Mg^{++}	K^{+}	Na+
8.18	7.69	24.67	0.33	20.73	3.06	_	17.08	4.00	8.12	32.47	16.29	10.29	1.2	4.05

Table (2): The monthly averages of weather factors for Fayoum region during 2009 and 2010 seasons

Month	Year	Temperature C°			Relative humidity (%)	Wind speed(m/sec)	Pan evaporation(mm/day)
		Max.	Min.	Mean			
June	2009	38.2	20.4	29.3	44	2.99	8.18
	2010	38.4	21.4	29.9	48	3.01	7.60
July	2009	38.5	22.7	30.6	47	2.58	8.41
	2010	36.3	22.4	29.3	50	2.58	8.60
August	2009	37.0	21.8	29.4	48	2.42	7.62
	2010	40.2	24.5	32.3	46	2.44	7.00
September	2009	35.2	20.7	27.9	50	2.58	6.69
	2010	36.2	21.9	29.1	50	2.60	6.10

Table (3): Some soil moisture constants and bulk density for the experimental field (average of 2009 and 2010 seasons)

Soil depth (cm)	Field capacity (%,wt)	Wilting point (%,wt)	Bulk density (gcm^{-3})	Available moisture (mm)
00-15	42.56	21.16	1.41	45.3
15-30	40.76	19.84	1.43	٤٤.٩
30-45	38.32	18.65	1.31	٣٨.٧
45-60	33.59	17.34	1.39	٣٣.٩

At harvesting time the following data were recorded for each sub-plot:-

I. Growth parameters, Yield and yield components

1- Plant height (cm) 2- N$^{\underline{o}}$ of leaves/plant 3- Stem diameter(cm)
4- Ear length (cm) 5- Ear diameter (cm) 6- Grain weight/plant (g)

7-100 -grain weight (g) 8-Grain yield, Kg/fed.

All the measurements and data collected were subjected to the statistical analysis according to the methods described by Snedecor and Cochran (1980).

II. Crop - water relations:

1. Seasonal consumptive use (ET_C)

On determining crop water consumptive use (ET_C), soil samples were taken48 hours after each irrigation and just before the next one, as well as at harvest time. The crop water consumptive use, between each two successive irrigations was calculated according to Israelsen and Hansen, 1962 as follows :-

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

Cu = crop water consumptive use (cm).
Q2= soil moisture percentage, by weight, 48 hours after irrigation.
Q1= soil moisture, by weight, just before the next irrigation.
Bd = soil layer bulk density (gcm^{-3}).
D = soil layer depth (cm).

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 mm/day using the monthly averages of weather factors of Fayoum region 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 (ET_C), mm and ET_0 = Reference evapotranspiration, mm.

5. Water Use Efficiency (WUE).

The water use efficiency as kg grains/ m^3 water consumed was calculated as described by Vites (1965):

WUE, kg grain/ m^3 = Grain yield, kg/fed. / Seasonal crop water consumptive use, m^3/fed.

RESULTS AND DISCUSSION

I – Growth parameters, yield and yield components

1- Growth parameters

The results in Table (4) show that increasing N-rate significantly affected maize growth parameters in both seasons. The highest growth parameters were obtained from applying 130 kg N/fed (F_3), whereas the lowest ones were detected from applying 90 kg N/fed in the two seasons. Increasing N- level from 90 to 110 kg N/fed caused a significant increase in plant height, leaves number/plant and stem diameter in 2009 season by 1.7, 2.7 and 7.67%, respectively, and in 2010 season by 2.23, 2.26 and 6.35%, respectively. In addition, the corresponding increase, in the forepassed parameters in 2009 season, due to increasing N- rate from 90 to 130 kg N/fed, reached 2.8, 4.4 and 11.7% and in 2010 season by 4.89, 4.16 and10.36%, respectively. These increments may be due to the role of nitrogen in stimulating amino acid building and growth hormones, which in turn acts positively on cell division and enlargement. These results are in the same trend with those obtained by Uhart and Rade (1995), El- Bana and Gomaa(2000), El-Douby *et al.* (2001) and Siam *et al.* (2008).

Table(4): Effect of N- rate , irrigation scheduling and their interaction on some growth parameters of maize in 2009 and 2010 seasons

Season		2009			2010		
N- rate	irrigation scheduling coefficient	Plant height (cm)	leaves Nº /plant	Stem Diameter (cm)	Plant height (cm)	leaves Nº /plant	Stem Diameter (cm)
F1 90kg N/fed	I_1 : 0.8	161	12.53	3.63	163	13.01	3.72
	I_2: 1.0	172	13.38	3.81	175	13.76	3.95
	I_3: 1.2	185	14.53	4.11	188	14.72	4.27
	Mean	173	13.48	3.85	175	13.83	3.98
F2 110kgN/fed	I_1 : 0.8	163	12.68	3.86	167	13.33	3.91
	I_2: 1.0	176	14.05	4.23	180	14.31	4.36
	I_3: 1.2	188	14.84	4.43	190	14.80	4.49
	Mean	176	13.86	4.17	179	14.15	4.25
F3 130kgN/fed	I_1 : 0.8	165	13.19	4.25	170	13.56	4.20
	I_2: 1.0	178	14.21	4.36	186	14.71	4.51
	I_3: 1.2	192	14.96	4.48	195	15.03	4.62
	Mean	178	14.10	4.36	184	14.43	4.44
Irrigation mean							
I_1 : 0.8		163	12.80	3.91	167	13.30	3.94
I_2: 1.0		175	13.88	4.13	180	14.26	4.27
I_3: 1.2		188	14.78	4.34	191	14.85	4.46
LSD, 5%							
F (N-rate)		1.60	0.21	0.02	4.67	0.13	0.02
I (Irrigation scheduling)		1.80	0.22	0.12	2.85	0.11	0.05
F × I		3.10	N.S	N.S	N.S	0.19	0.09

Data in Table (4) indicate that irrigating maize plants at 1.2 C.P.E. gave the highest averages of growth parameters, whereas the lowest ones were detected from irrigation at 0.8 C.P.E. These results were true in both seasons.

Irrigation at 1.0 C.P.E. reduced the plant highest, leaves number/plant and stem diameter in season 2009 by 6.91, 6.09 and 4.84% and in 2010 season by 5.76, 3.97 and 4.26%, respectively, as compared with irrigation at 1.2 C.P.E. Such findings can be attributed to the more available moisture in the root zone resulted from irrigating at1.2 C.P.E., which in turn increased photosynthesis rate, cell division and dry matter accumulation. The obtained results are in agreement with those found by EL- Noemany *et al.* (1990) , Ibrahim *et al.* (1992) and Atta- Allah (1996).

Results in Table (4) reveal that the interaction between N- rates and irrigation treatments exerted a significant effect on plant height in 2009 season and number of leaves/plant and stem diameter in 2010 season only. The highest growth parameters were obtained under 130 kg N/fed rate as interacted with irrigation at 1.2 C.P.E., meanwhile, the lowest ones were resulted from N- rate of 90 kg N/fed and irrigation at 0.8 C.P.E. interaction in both seasons.

2- Yield and yield components

Data in Table (5) show that the averages of maize grain yield and its components were differed significantly due to different N- rates in both seasons. Applying 130 kg N/fed gave the highest averages of grain yield reached 2429.0 and 2601.38 kg/fed in 2009 and 2010 seasons, respectively. The yield components e.g. ear length, ear diameter, grain weight/plant and 100-grain weight comprised 19.70 (cm), 5.49(cm), 175.89(g) and 30.16(g), respectively, in 2009 season. The corresponding yield components figures, in 2010 season, reached 20.53 (cm), 5.51 (cm), 181.79 (g) and 33.17 (g), respectively. Reducing N- rate from 130 to 110 kg N/fed, significantly reduced grain yield, ear length, ear diameter, grain weight/plant and 100-grain weight in 2009 season by 17.89, 10.20, 6.19, 3.09 and 1.72%, respectively, and in 2010 season by 16.81, 9.11, 5.63, 3.91 and 5.76%, respectively. As N- rate reduced to be 90 kg N/fed, the lowest grain yield and yield components were noticed where the reductions in grain yield, ear length, ear diameter, grain weight/plant and 100-grain weight reached 24.52, 16.24, 13.66, 6.65 and 5.87% in 2009 season, respectively, as compared with 130 kg N/fed rate. The corresponding reduction values, in 2010 season comprised 23.60, 15.59, 11.98, 4.85 and8.50%, respectively. These results confirm the findings of El-Bana and Gomaa (2000), El-Douby *et al.* (2001) and Siam *et al.* (2008).

The results in Table (5) indicate that irrigation treatments exerted a significant effect on maize grain yield and its components in both seasons. Irrigation at 1.2 C.P.E. (short irrigation cycle) gave the highest grain yield

Table 5

which amounted to 2362.83 and 2468.29 kg/fed in both seasons, whereas, the lowest grain yield e.g. 1889.02 and 2109.59 kg/fed were detected from irrigation at 0.8 C.P.E. (wide irrigation cycle) in the two seasons.

Furthermore, increasing irrigation scheduling coefficient from 0.8 to 1.2 C.P.E. significantly increased the yield attributes e.g. ear length, ear diameter, grain weight/plant and 100-grain weight in2009 season by 10.30, 12.55, 21.01 and 5.27%, respectively, and in 2010 season by 18.04, 10.55, 18.18 and 6.64%, respectively. The obtained results are in agreement with those found by Musck and duesk (1980), El- Noemani *et al.* (1990), Ibrahim *et al.* (1992), Sharaan *et al.* (2002), El-Tantawy *et al.* (2007) and Abdel-Maksoud *et al.* (2008).

Data in Table (5) reveal that averages of maize yield and its components were significantly affected by the interaction between N- rates and scheduling irrigation treatments in both seasons (except ear length in 2009 season). The highest averages of yield and yield components attributes were observed under 130 kg N/fed rate as interacted with irrigation at 1.2 C.P.E., whereas the lowest ones were obtained from N- rate at 90 kg N/fed under irrigation at 0.8 C.P.E. and such results were true in both seasons of study.

II – Crop water relations

1- Seasonal consumptive use (ET_C).

The results in Table (6) show that the values of seasonal consumptive use (ET_C) of maize crop, as a function of ammonia fertilizer rates and scheduling irrigation treatments interaction, were 59.41 cm and 61.21 cm in 2009 and 2010 seasons, respectively.

Increasing N fertilizer rates from 90 to 110 or 130 kg N/fed increased the seasonal ET_C by 3.28 and 5.74% in 2009 season, and by 1.82 and 4.96% in 2010 season, respectively. These results may be due to that the increase in N- rate led to an increase in all growth parameters which increase the evapotranspiration. These results are in full agreement with those obtained by Doorenbos *et al.* (1979), Ainer (1983), Sadik et al. (1995) and Elvio and Michele(2008). Data indicate that irrigation at 1.2 C.P.E (narrow irrigation cycle) gave the highest values of seasonal ET_C, reached 61.35 and 62.84 cm in 2009 and 2010 seasons, respectively. Whereas, the lowest ET_C values, i.e. 57.43 and 59.65 cm were resulted from irrigation at 0.8 C.P.E (wide irrigation cycle) in 2009 and 2010 seasons, respectively.. Increasing C.P.E. coefficient from 0.8 to 1.0 or 1.2 C.P.E increased seasonal ET_C by 3.40 and 6.39% in 2009 season and in 2010 season by 2.81 and 5.08%, respectively. These results may be attributed to that irrigation at 1.2 C.P.E (frequent irrigation) increased the available soil moisture in the root zone of plants and this may increase both transpiration process from the plant vegetation and surface soil evaporation. These results are in harmony with those found by Sharaan *et al.* (2002), El-Tantawy *et al.* (2007) and Abdel-Maksoud *et al.*(2008).

Regarding, the interaction effect, data Table (6) show that application of 130 kg N/fed. and irrigation at 1.2 C.P.E gave the highest value of seasonal

ET_C in seasons, i.e. 63.11 and 64.73 cm, in 2009 and 2010 seasons, respectively, while application of 90 kg N/fed. and irrigation at 0.8 C.P.E gave the lowest value of seasonal ET_C reached 55.84 and 58.47 cm in 2009 and 2010 seasons, respectively.

Table (6): Effect of N- rate, irrigation scheduling and their interaction on seasonal water consumptive use of maize crop ($ET_{C,}$ cm)

N - rate	2009 season				2010 season			
	Irrigation scheduling coefficient			Mean	Irrigation scheduling coefficient			Mean
	0.8 CPE	1.0 CPE	1.2 CPE		0.8 CPE	1.0 CPE	1.2 CPE	
(F_1) 90 kg N/fed	55.84	57.31	59.61	57.59	58.47	59.55	61.37	59.80
F_2)110 kg (N/fed	57.56	59.72	61.33	59.54	59.48	60.84	62.41	60.91
F_3)130 kg (N/fed	58.88	61.31	63.11	61.10	61.01	63.01	64.73	62.92
Mean	57.43	59.45	61.35	59.41	59.65	61.13	62.84	61.21

2-Daily ET_C rate (mm/day).

The data in Table (7) generally in the two seasons of study, indicate that the daily ET_C rates, as a function of the different treatments under this study started with low values during June (3.59 and 3.59 mm/day), then increased during July (5.64 and 5.57 mm/day), and reached its maximum values (6.78 and 7.02 mm/ day) during August and declined again during September to reach its low value at harvest(4.42 and 4.36 mm/day). Such findings may be attributed to that during June most of water losses are due to evaporation from the bare surface soil. Thereafter, daily Etc rate was increased as the crop cover increased and reached the peak rate at tassling and silking stages. The ETc tended to reduce again during September (grain filling and maturity stages). Data in Table(7) show that reducing the N- rate from 130 to 110 or 90 kg N/fed resulted in reduction in daily Etc rate during entire growing season and such findings were true in 2009 and 2010 seasons.

Data in Table (7) reveal that irrigating maize crop at 1.2 C.P.E.(frequent irrigation) increased the daily ETc rate, meanwhile, with 0.8 C.P.E.(wide irrigation cycle) resulted in lower values during the entire growing season. These results may be due to the higher available soil moisture in effective root zone, as the crop was irrigated at 1.2 C.P.E., which consequentially increased evapotranspiration rate. The obtained results are in accordance with those reported by EL-Tantawy *et al.* (2007) and Abdel- Maksoud *et al.* (2008).

The interaction data reveal that the highest daily ETc rate values were obtained due to 130 kg N/fed rate and irrigating at 1.2 C.P.E. and such findings were true in 2009 and 2010 seasons.

Table (7): Effect of N- rate, irrigation scheduling and their interaction on daily water consumption use (mm/day) in 2009 and 2010 seasons

N-rate	Irrigation scheduling coefficient	2009 season				2010 season			
		June	July	August	Sep.	June	July	August	Sep.
F1 90 kg N/fed	0.8	3.57	5.21	6.26	4.16	3.57	5.30	6.59	4.36
	1.0	3.57	5.37	6.48	4.29	3.57	5.38	6.81	4.42
	1.2	3.57	5.61	6.84	4.48	3.57	5.62	7.10	4.49
	Mean	3.57	5.40	6.53	4.31	3.57	5.43	6.83	4.42
F2 110 kg N/fed	0.8	3.57	5.45	6.48	4.29	3.57	5.38	6.73	4.49
	1.0	3.57	5.69	6.84	4.42	3.57	5.54	6.96	4.55
	1.2	3.57	5.85	7.06	4.61	3.57	5.77	7.18	4.62
	Mean	3.57	5.66	6.79	4.44	3.57	5.56	6.96	4.55
F3 130 kg N/fed	0.8	3.57	5.61	6.70	4.35	3.57	5.54	6.96	4.62
	1.0	3.66	5.85	7.06	4.48	3.65	5.77	7.25	4.68
	1.2	3.66	6.08	7.27	4.67	3.65	5.85	7.62	4.81
	Mean	3.63	5.85	7.01	4.50	3.62	5.72	7.28	4.70
Irrigation mean									
0.8		3.57	5.42	6.48	4.27	3.57	5.41	6.76	4.49
1.0		3.60	5.64	6.79	4.40	3.60	5.56	7.01	4.55
1.2		3.60	5.85	7.06	4.59	3.60	5.75	7.30	4.64
Overall mean		3.59	5.64	6.78	4.42	3.59	5.57	7.02	4.56

3-Reference evapotranspiration (ET_0).

The daily ET_0 rate during maize growing season in 2009 and 2010 seasons are presented in Table (8). The daily ET_0 value (mm/day) were calculated using the FAO-Penman-Monteith equation and meteorological data of Fayoum region(Table, 2), from June to September in 2009 and 2010 seasons. The results indicate that the daily ET_0 rate started with high values during June and slowly decreased during July with continuous decrease during August and September, in both seasons. These results can be attributed to the changes in whether factors from month to the other. In this connection,

Allen *et al.* (1998), reported that the values of ET_0 are depend mainly on the air evaporative power such as temperature, humidity, wind speed and solar radiation.

4 –Crop coefficient (K_C).

The crop coefficient reflects the effect of crop cover percentage and soil conditions on the ET_0 values. The K_C values were estimated from the daily ET_C rates (Table, 7) and the daily ET_0 rates (Table, 8) during the two growing seasons. The results in Table (8) reveal that the K_C values, as a function of the interaction N- fertilizer rates and irrigation scheduling treatments (as overall mean) were low during June (initial growth stages) which reached 0.42 and 0.43 in the two successive seasons. Thereafter, Kc values increased to 0.71and 0.71 during July (vegetative growth stage) to reached its maximum values during August to 0.94 and 0.95 (taslling and silking stages) in the two successive season, respectively. The K_C values seem to decrease again during September to 0.69 and 0.70 in the two seasons (grain filling-maturity and harvesting stages). Such results can be referred to the large diffusive resistance to bare soil at the initial stage, which reduced with increasing the crop cover percentage until heading and grain formation, and then tended to be reduced again at maturity stage. Data in Table (8) show that reducing N- rate from130 to 110 or 90 kg N/fed decreased the K_C values during the growing season and this trend was similar in both seasons. The rate 130 kg N/fed gave the highest K_C values, whereas, the lowest values were detected under the rate of 90 kg N/fed in the two growing seasons. On the other hand, decreasing irrigation coefficient from 0.8 to 1.0 and 1.2 C.P.E increased the K_C values entire the growing season in both 2008 and 2009 seasons.

Finally, maize K_C values, for high yielding interaction i.e. F_3I_3, were 0.43, 0.77, 1.01 and0.73 in 2009 season, and 0.44, 0.75, 1.03 and 0.74 in 2010 season, at June, July, August and September, respectively.

5- Water use efficiency (WUE).

The results in Table (9) show clearly that the mean values of WUE as a function of different tested treatments were 0.833 and 0.881 kg grains/m^3 water consumed in 2009 and 2010 seasons, respectively. The highest values of WUE in 2009 and 2010 seasons were detected from applying ammonia gas at the rate of 130 kg N/fed, i.e. 0.944 and 0.982 kg grains/m^3 water consumed, meanwhile, adding ammonia gas at rate of 90 kg N /fed gave the lowest WUE value in 2009 and 2010 seasons i.e. 0.757 and 0.803 kg grains/m^3 water consumed, respectively.

Table (8): Reference evapotranspiration, ET_0 (mm/day) and K_C for maize crop during 2009 and 2010 seasons as affected by N- rate, irrigation scheduling and their interaction

N-rate	Irrigation Scheduling coefficient	2009 season				2010 season			
		June	July	Aug.	Sept.	June	July	Aug.	Sept.
Reference ET_0 mm/day		8.5	7.9	7.2	6.4	8.3	7.8	7.4	6.5
F_1 90 kg N/fed	0.8	0.42	0.66	0.87	0.65	0.43	0.68	0.89	0.67
	1.0	0.42	0.68	0.90	0.67	0.43	0.69	0.92	0.68
	1.2	0.42	0.71	0.95	0.70	0.43	0.72	0.96	0.69
	Mean	0.42	0.68	0.91	0.67	0.43	0.70	0.92	0.68
F_2 110 kg N/fed	0.8	0.42	0.69	0.90	0.67	0.43	0.69	0.91	0.69
	1.0	0.42	0.72	0.95	0.69	0.43	0.71	0.94	0.70
	1.2	0.42	0.74	0.98	0.72	0.43	0.74	0.97	0.71
	Mean	0.42	0.72	0.94	0.69	0.43	0.71	0.94	0.70
F_3 130 kg N/fed	0.8	0.42	0.71	0.93	0.68	0.43	0.71	0.94	0.71
	1.0	0.43	0.74	0.98	0.70	0.44	0.74	0.98	0.72
	1.2	0.43	0.77	1.01	0.73	0.44	0.75	1.03	0.74
	Mean	0.42	0.74	0.97	0.70	0.44	0.73	0.98	0.72
Irrigation mean									
0.8		0.42	0.69	0.90	0.67	0.43	0.69	0.91	0.69
1.0		0.42	0.71	0.94	0.69	0.43	0.71	0.95	0.70
1.2		0.42	0.74	0.98	0.72	0.43	0.74	0.99	0.71
Over all mean		0.42	0.71	0.94	0.69	0.43	0.71	0.95	0.70

Data listed in Table (9) indicate that irrigation at 1.2 C.P.E gave the highest WUE values, i.e. 0.915 and 0.932 kg grains/m^3 water consumed in 2009 and 2010 seasons, respectively, whereas, the lowest values of WUE, i.e. 0.782 and 0.841 kg grains/m^3 water consumed was detected from 0.8 C.P.E in 2009 and 2010seasons, respectively.

Data of interaction in Table (9) show that the highest WUE values, i.e. 1.072 and 1.117 kg grains/m^3 water consumed was obtained from (F_3I_3) in 2009 and 2010 season, whereas, the lowest ones i.e. 0.710 and 0.780 kg grains/m^3 water consumed were obtained under interaction of (F_1I_1) in 2009 season. These results are in harmony with the results reported by El-Tantawy *et al.* (2007) and Abdel-Maksoud *et al.* (2008).

On conclusion, to maximize the maize crop (grown at Fayoum region) productivity and water use efficiency as well as, it is advisable to fertilize

maize (hybrid (TWC 310) with liquid ammonia gas at the rate of 130 kg N/fed and irrigating at 1.0 or 1.2 C.P.E.

Table (9): Effect of N- rate, irrigation scheduling and their interaction on water use efficiency of maize in 2009 and 2010 seasons

N-rate	2009 season				2010 season			
	Irrigation scheduling coefficient				Irrigation scheduling coefficient			
	0.8	1.0	1.2	Mean	0.8	1.0	1.2	Mean
(F_1) 90 kg N/fed	0.710	0.729	0.832	0.757	0.780	0.809	0.819	0.803
(F_2)110 kg N/fed	0.784	0.767	0.841	0.797	0.856	0.857	0.861	0.858
(F_3)130 kg N/fed	0.853	0.908	1.072	0.944	0.888	0.941	1.117	0.982
Mean	0.782	0.801	0.915	0.833	0.841	0.869	0.932	0.881

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إدراة المياه لمحصول الذرة الشامية تحت التسميد بالامونيا الغازية

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الملخص العربي

أقيمت تجربتان حقليتان بمزرعة محطة البحوث الزراعية بطامية – محافظة الفيوم – خلال موسمي الزراعة صيف ٢٠٠٩ ، ٢٠١٠ لدراسة تأثير التسميد بالامونيا الغازية وجدولة الري علي بعض قياسات النمو ومحصول الذرة الشامية ومكوناته (صنف هجين ثلاثي ٣١٠) وبعض العلاقات المائية للمحصول . ولتحقيق ذلك تفاعلت ثلاثة معدلات لاضافة الامونيا الغازية وهي (٩٠ ، ١١٠ ، ١٣٠ كجم ن / فدان) مع ثلاث معاملات لجدولة الري وهي (١) الري عند ٠.٨ ، (٢) الري عند ١.٠ ، (٣) الري عند ١.٢ من البخر التراكمي لوعاء البخر القياسي في تصميم القطع المنشقة مرة واحدة في اربعة مكررات . وفيما يلي ملخص لأهم النتائج المتحصل عليها:–

٦. **تأثرت قياسات النمو المدروسه و محصول الفدان ومكونات المحصول معنويا بمواعيد الزراعة وكذلك بمعاملات جدولة الري وقد أدي إضافة الامونيا الغازية بمعدل ١٣٠ كجم ن / فدان والري عند ١,٢ من بخر الوعاء التراكمي للحصول علي أعلي متوسطات لارتفاع النبات وعدد الاوراق علي النبات وقطر الساق وطول وقطر الكوز ووزن الحبوب/نبات ووزن ال١٠٠ حبه في كلا الموسمين ، بينما ادي اضافة ٩٠ كجم ن/فدان والري عند ٠,٨ من بخر الوعاء التراكمي للحصول علي اقل المتوسطات لقياسات النمو ومكونات المحصول.**

٧. **نتج أعلي متوسط محصول حبوب(٢٨٤١,٥٥ ، ٣٠٣٨,١٣ كجم حبوب/فدان) من التسميد ب ١٣٠ كجم ن/فدان والري عند ١,٢ من بخر الوعاء التراكمي، وفي المقابل ادي التسميد ب ٩٠ كجم ن/فدان والري عند ٠,٨ من بخر الوعاء التراكمي للحصول علي اقل المتوسطات وكانت ١٦٦٣,٨٧ ، ١٩١٥,١٣ كجم حبوب/فدان في موسمي ٢٠٠٩ ، ٢٠١٠ علي الترتيب.**

٨. **كان متوسط الاستهلاك المائي الموسمي للتفاعل بين المعاملات هو ٥٩,٤١ ، ٦١,٢١ سم في موسمي ٢٠٠٩ ،٢٠١٠ علي الترتيب وكانت أعلي قيم للاستهلاك لمائي الموسمي وهي**

٦٣,١١ ، ٦٤,٧٣ سم في ٢٠٠٩ ، ٢٠١٠ علي الترتيب قد نتجت من التسميد ب ١٣٠ كجم ن/فدان والري عند ١,٢ بخر تراكمي للوعاء وكانت أقل قيم للاستهلاك المائي الموسمي وهي ٥٥,٨٤ ، ٥٨,٤٧ سم قد نتجت من التسميد ب ٩٠ كجم ن/فدان والري عند ٠,٨ بخر تراكمي للوعاء في الموسمين المتعاقبين.

٩. كان معدل الاستهلاك المائي اليومي للمحصول منخفضأ خلال يونية ثم إزداد خلال يوليو ليصل الي قمة الاستهلاك خلال أغسطس ثم انخفض خلال سبتمبر في كلا الموسمين ، وكان ثابت المحصول للمعاملة التي اعطت أعلي محصول حبوب (كمتوسط للموسمين) هو ٠,٤٣ ، ٠,٧١ ، ٠,٩٥ ، ٠,٧٠ خلال يونيو ويوليو وأغسطس وسبتمبر علي الترتيب.

١٠. نتجت أعلي كفاءة استهلاك للماء وهي ١,٠٧٢ ، ١,١١٧ كجم حبوب/ م٣ ماء مستهلك في ٢٠٠٩ ، ٢٠١٠ علي الترتيب من التسميد ب ١٣٠ كجم ن/فدان والري عند ١,٢ بخر تراكمي للوعاء في الموسمين المتعاقبين.

Table (5): Effect of N- rate, irrigation scheduling and their interaction on maize yield and its components in 2009 and 2010 seasons

Treatments		2009 season					2010 season				
N-fertilization rate	Irrigation Scheduling coefficient	Ear length (cm)	Ear diameter (cm)	Grain weight ear (gm)	100-grain weight (gm)	Grain yield Kg/fed	Ear length (cm)	Ear diameter (cm)	Grain weight ear (gm)	100-grain weight (gm)	Grain yield Kg/fed
F_1	I_1: 0.8	15.25	4.37	145.38	27.36	1663.87	15.91	4.62	157.38	29.30	1915.13
	I_2:1.0	16.76	4.79	165.63	28.58	1754.23	17.18	4.86	173.23	29.95	2023.38
	I_3:1.2	17.50	5.06	182.13	29.23	2081.75	18.91	5.07	188.30	31.81	2111.00
Mean		16.50	4.74	164.38	28.39	1833.28	17.33	4.85	172.97	30.35	2016.50
F_2	I_1: 0.8	16.79	4.97	155.13	29.15	1894.57	16.94	4.99	153.15	30.04	2139.13
	I_2:1.0	17.39	5.10	166.14	29.80	1923.61	18.72	5.11	178.81	31.24	2188.88
	I_3:1.2	18.90	5.39	190.13	29.98	2165.19	20.31	5.50	192.11	32.51	2255.75
Mean		17.69	5.15	170.46	29.64	1994.46	18.66	5.20	174.69	31.26	2194.59
F_3	I_1: 0.8	17.25	5.10	146.38	29.23	2108.61	18.11	5.14	160.59	32.56	2274.50
	I_2:1.0	19.38	5.32	187.79	29.95	2336.84	20.52	5.46	189.40	32.85	3038.13
	I_3:1.2	22.48	6.04	193.50	31.31	2841.55	22.96	5.92	195.38	34.11	2601.38
Mean		19.70	5.49	175.89	30.16	2429.00	20.53	5.51	181.79	33.17	2638.00
Irrigation Mean											
	I_1: 0.8	16.43	4.81	148.96	28.58	1889.02	16.99	4.92	157.04	30.63	2234.59
	I_2:1.0	17.84	5.07	173.18	29.44	2004.89	18.81	5.14	180.49	31.35	2468.29
	I_3:1.2	19.63	5.50	188.59	30.17	2362.83	20.73	5.50	191.93	32.81	
L.S.D.: 5%											
F		1.05	0.09	4.88	0.13	66.87	0.16	0.03	3.75	0.03	58.24
I.		0.14	0.06	2.68	0.19	42.92	0.15	0.05	1.62	0.02	39.93
F×I		N.S	0.10	4.64	0.34	74.33	0.26	0.09	2.80	0.03	69.93