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IRRIGATION SCHEDULING OF CORN (*Zea Mays L.*) IN MIDDEL EGYPT

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ABSTRACT: Two field experiments were carried out at Giza farm, Agric. Res. Center Giza Governorate during 2004 and 2005 seasons to study the effect of water stress, using pan coefficient (selected from 0.8, 1.0, 1.2 and 1.4 treatments (IW: CPE) using pan evaporation records under 3 planting dates (15th May, 5th June and 25th June) and 2 levels of potassium (24 and 36Kg K_2O/ Fed.)on evapotranspiration rates from corn crop*(Zea Mays L.)*. Results of the two maize growing seasons indicated that, seasoned water consumptive use values were 673.0 and 690.4mm. in the first and second seasons, respectively. Also results indicated that the most efficient method for calculating corn crop evapotranspiration (ETC) in Middle Egypt is Doorenbos-Pruitt followed by penman Monteith and modified Penman Formulae The present study aims to identifying the effective evaporation pan coefficient selected from 0.8, 1.0, 1.2 and 1.4 (IW: CPE) ratio for scheduling irrigation of corn under different planting dates and rate of potassium fertilizer.

Key words: Irrigation water cumulative pan evaporation ratio (IW:CPE).

INTRODUCTION

Maize *(Zea mays L.)* is one of the most important cereal crops in the world. It ranks the third of the world cereal crops after wheat and rice. In Egypt it is cultivated in nearly two millions feddan. Plants vary in the timing of their high need for water, this need by different plant species depend on how much moisture stress they are able to tolerate at any particular stage of growth. Water is the limiting factor of agriculture in arid and semiarid regions. The response to potassium fertilizer depends on the level of available soil moisture and hence the

irrigation practices need to be modified.. In this context, Jensen and Middleton (1965) described and applied the accumulative pan evaporation pan method for scheduling irrigation in USA. Eid *et al.*, (1982) in Egypt used the evaporation pan method for Scheduling irrigation. El-Marsafwy (1995) in Giza identified the effective evaporation pan coefficient for maize crop. However many scientists made an attempt to evaluate the effective evaporation coefficients in Middle Egypt (Yousef 1989), (El- Garhi *et al.* 2003) and many others are being done for the same purpose. However Abdalla *et al.*, (2000) reported that the increase in the consumptive use of water could be mainly due to the increase of the moisture content in the soil. Abdel-Aziz *et al.* (2004) indicated that the values of seasonal water consumptive use by maize ranged from 546.6 to 746.4 mm. fad.

MATERIALS AND METHODS

The present investigation was carried out at Giza farm, Agric. Res. Center during 2004 and 2005 season to study the effect of water stress, using pan coefficient (selected from 0.8, 1.0, 1.2 and 1.4 treatments (IW: CPE) using pan evaporation records) under 3 planting dates and two levels of potassium fertilizer on the actual seasonal evapotranspiration (Consumptive water use) on corn crop*(Zea mays L.)* .The experiment was conducted in split split plot design with four replicates each some physical and moisture characters of Gize experimental farm are shown in Table1.

Table 1. Some physical and moisture characters of Gize experimental farm

Soil characters	Content percentage			
Particle size distribution				
Coarse sand	3.31			
Fine sand	13.26			
Silt	30.33			
Clay	53.10			
Textural class	clay			
Moisture content at	**0-15**	**15-30**	**30-45**	**45-60**
Field capacity	39.90	33.50	27.95	28.35
Wilting point	18.40	17.65	16.60	16.40
Available water	21.50	15.85	11.35	11.95
Bulk density gm/cm^3	1.16	1.22	1.25	1.29

However the main treatments were water stress treatments (evaporation pan coefficient): 0.8, 1.0, 1.2 and 1.4 represent (prolonged- dry treatment), (infrequent), (medium) and (frequent), respectively. Whereas the sup- plots were date of planting (15^{th} May, 5^{th} June and 25^{th} June). The sub-sub plots were potassium fertilizer levels, Which were 24 and 36 Kg K_2O/ Fad. The nitrogen fertilizer was added in the form of ammonium Salfate (20%N). The other normal agriculture practices were adopted as recommended by Ministry of agriculture . Actual consumptive use (ETa), Seasonal consumptive water use (evapotranspiration) and monthly C. W. U were recorded.

The actual evapotranspiration (ETa) was estimated from the soil sampling. Soil samples were taken before and after irrigation as well as at harvest time to calculate consumptive water use according to the equation of Israelsen and Hansen (1962). The monthly consumptive water use were obtained from daily water use multiplied by the number of days in the month. Potential evapotranspiration (ETP) were estimated using three different empirical equations, i. e Penman Modified, Penman Monteith and Doorenbos- Pruitt where as the "WATER" model (Zazueta and Samjstrla 1984) was used to calculate the reference evapotra-nsiration the "CROPWAT" model (Smith 1991) was used to calculate (ETP) values for penman- Monteith equation.

Some meteorological data of Giza region are shown in Table2.

Table 2. Some meteorological data of Giza Agricultural Research station in 2004 and 2005 seasons

season	2004								2005							
Month	Tmax	Tmin	W.S	R.H	R.F	S.S	S.R	Epan	Tmax	Tmin	W.S	R.H	R.F	S.S	S.R	Epan
May	32.4	20.4	2.60	48.3	-	10.8	224.6	7.3	31.5	19.1	3.9	49.7	-	10.8	337	7.4
June	33.8	23.0	3.53	53.0	-	12.0	305.0	8.2	33.9	23.8	3.9	50.7	-	12.0	337	8.3
July	35.5	25.3	3.30	56.6	-	11.7	285.1	7.9	35.2	23.8	2.8	54.0	-	11.7	241.9	7.1
August	34.0	25.4	3.30	57.0	-	11.1	285.1	6.3	35.1	25.7	3.4	57.7	-	11.1	293.8	6.5
September	32.00	22.23	3.90	63.00	-	10.3	337.0	5.30	33.96	23.20	2.90	57.70	-	10.3	250.6	5.4

Where:
Tmax. Tmin = maximum and minimum temperatures C°.
W.S = wind speed(m/ sec.). R.H = Relative humidity (%).
R.F = rain fall (m.m). S.S = Actual sun shine (hour).
S.R = solar radiation(cal cm^2 / day). And Epan = Evaporation pan (mm /day).

RESULTS AND DISCUSSION

Seasonal Actual Consumptive Water Use (ETa):

Seasonal actual consumptive water use as affected by water stress, date of planting and potassium fertilizer levels are recorded in Table 3. The general average values irrespective to water stress, planting date and potassium fertilization level together were 673.0 and 690.4 mm. for first and second seasons, respectively. With respect to water stress, ETa values in 2004 were 619.0, 655.5, 688.4 and 724.2 mm. for 0.8, 1.0, 1.2 and 1.4 (IW:CPE) ratio, respectively.

The corresponding values in 2005 were 636.5, 668.5, 406.4 and 750.2 mm. taken the same order.

It is clear that ETa gradually increased as the available soil moisture increased in the root zone of corn plants. (i.e. short irrigation intervals increased ETa values).

However subjecting maize plants to water stress reduced the ETa values. In this respect Ghazy (2004) reported that treatment irrigated at 40% depletion of available soil moisture consumed water more than the other treatment which was irrigated at 85% depletion of available soil moisture.

These results-in general- could be supported by those reported by Ragab *et al.*, (1986), Sadik *et al.*, (1995), Ghazy (2002) and Ragab *et al.*, (2002). They confirmed that water consumptive use increased as soil moisture content increased. Regarding to planting date ETa values in 2004 were 688.3, 708.7 and 622.0mm. for 15th May, 5th June and 25th June planting dates, respectively.

The values in 2005 were 706.2 , 720.3 and 644.7mm for the same respective treatments. These resultes indicated that ETa values were increased with delaying planting dates till 5th June then it decreased at 25th June. Furthermore data recorded in Table 3 revealed that increasing potassium fertilizer level led to increased ETa of the maize crop.

The average obtained values in 2004 were 664.1 and 681.9mm. Whereas in 2005 were 676.0 and 704.8mm for 24 and 36 Kg K_2O / fadden, respectively. However results indicated that ETa values were increased by late planting in both seasons, Regarding the interaction between the three studied treatments table (3) showed that the highest value of

Table 3. Seasonal consumptive water use in mm of maize as affected by water stress, date of sowing and potassium fertilizer levels in 2004 and 2005 seasons

Irrigation regime	K_{2o} (kg / fed.)	2004				2005			
		Sowing dates							
		15th May	5th June	25th June	Average	15th May	5th June	25th June	Average
0.8	24	629.9	643.2	558.1	610.3	631.1	649.3	595.6	625.3
	36	643.1	667.0	572.7	627.7	653.5	671.7	618.0	647.7
Average		636.5	655.1	565.4	619.0	642.5	660.5	606.8	636.5
1.0	24	660.0	683.0	593.0	645.3	660.4	673.2	610.1	647.9
	36	674.8	705.8	616.6	665.7	705.4	720.0	641.7	689.0
Average		667.4	694.4	604.8	655.5	682.9	696.6	625.9	668.5
1.2	24	696.5	709.0	634.7	680.1	725.3	737.0	631.4	697.9
	36	716.1	726.0	647.7	696.6	747.3	750.8	646.5	714.9
Average		706.3	717.5	641.2	688.4	736.3	743.9	638.9	706.4
1.4	24	734.9	759.4	668.1	720.8	743.0	764.40	691.3	732.9
	36	751.2	776.4	684.9	737.5	783.8	795.5	723.1	767.4
Average		743.1	767.9	676.5	729.2	763.4	780.0	707.0	750.2
Average for all k_{2o} levels	24	680.3	698.7	613.5	664.1	690.0	706.0	632.1	676.0
	36	696.3	718.8	630.5	681.9	722.5	734.5	657.3	704.8
Average of sowing dates		688.3	708.7	622.0	673.0	706.2	720.3	644.7	690.4

ETa was obtained at 1.4 (IW: CPE) ratio with treatment of 5th June planting date and 36 Kg K_2O/faddan. Whereas, the lowest value was recorded at 0.8 (IW: CPE) ratio with 25th June planting date and 24 Kg K_2O/ faddan.

The monthly consumptive water use values as affected by different treatments are recorded in Table 4. Monthly ETa values for water stress were increased by increasing number of irrigation (i. e. 1.4 pan evaporation coefficient) in the two seasons. The highest monthly Eta values were recorded through July in all treatments. This can be attributed to the increase in air temperature and to the vigorous growth of maize plants. Monthly ETa values were increased when maize planted on 5th June and 25th June. The results are in full agreement with those found by khedr *et al*, (1996) which reported that monthly water consumptive use started low at the beginning of the growing season, after that it increased gradually and reached it's maximum values in July and August then it declined at the end of the season. Furthermore Table 4 revealed that ETa values were increased by increasing potassium fertilizer level. Regarding the values of ETa and ET crop (mm/ month) estimated by modified penman, penman Monteith and Doorenobs- Pruitt as recorded in Table 5 , the data revealed that in 2004 and 2005 seasons ET crop values were 7.31, 6.92, 5.80 and 7.49, 7.03 and 5.84 mm / day for modified penman, penman Monteith and Doorenobs- Pruitt formulae, respectively. Generally, results recorded in Table 5 showed that modified penman formula gave the maximum value, while Doorenobs - Pruitt gave the minimum one. Whereas values of penman Monteith was found to be in between for the two seasons. Whereas comparing ETa with the Actual ET, data recorded in Table 5 rivaled that the average ratios between ET crop/ Actual ET were 0.7, 0.7 and 0.9 for modified Penman, Penman monteith Doorenbos - Bruitt, Respectively.

The obtained data of Table 5 evidence that Doorenbos - Bruitt formula has the superior in calculating ET crop for maize in Middle Egypt, due to it's least difference from the actual ETa value compared with other formulae.

Regarding to soil moisture extraction paterns, Table 6 showed that values of soil moisture extraction pattern within the root zoon of 60 cm as effected by water stress, date of planting and

Table 4. Monthly consumptive water use, cm as affected by water stress, planting dates and potassium fertilization levels in 2004 and 2005 seasons

Seasons	2004				2005				2004			2005			2004		2005	
Treatments	Irrigation regime								Planting dates						Potassium levels K_{2o}			
Month	0.8	1.0	1.2	1.4	0.8	1.0	1.2	1.4	15th May	5th June	25th June	15th May	5th June	25th June	Kg K_{2o} / Fadden			
															24	36	24	36
May	67.2	67.2	67.2	67.2	65.6	65.6	65.6	65.6	67.2	-	-	65.6	-	-	67.2	67.2	65.6	65.6
June	156.9	159.0	161.7	174.6	161.4	172.8	188.1	195.0	161.7	174.6	187.5	188.1	198.3	213.0	157.8	161.7	181.5	181.1
July	211.7	229.1	257.0	277.8	232.5	239.6	253.6	277.8	257.0	277.8	274.4	253.6	269.1	243.0	253.3	257.0	249.9	253.6
August	149.4	163.1	163.1	166.8	156.2	164.6	171.1	180.4	163.1	191.3	197.8	171.1	195.0	218.9	159.7	163.1	166. 8	171.1
September	33.8	37.1	39.4	42.8	20.8	25.9	28.0	31.4	39.4	100.6	138.3	28.0	97.2	125.3	38.1	39.4	27.5	28.0
Total	619.0	655.5	688.4	729.2	636.5	668.5	706.4	750.2	688.4	744.3	798.0	706.4	759.6	800.9	676.1	688.4	691.3	706.4
Average	123.8	131.1	137.7	145.8	127.3	133.7	141.3	150.0	137.7	138.8	187.4	141.3	189.9	160.0	135.2	137.7	138.3	141.3

* irrigation based on irrigation water cumulative pan evaporation(IW:CPE) record ratio 0.8, 1.0, 1.2 and 1.4.

Table 5. Potential ET (Estemated by) different methods) and actual consumptive water use by maize (mm / day) in 2004 and 2005 Seasons

Season	2004		2005		Average	
Formulae	**ET**	**Ratio**	**ET**	**Ratio**	**ET**	**Ratio**
Penman monteith **	6.92	0.8	7.03	0.8	7.11	0.7
Doorenbos- Pruitt*	5.80	0.9	5.84	1.0	5.82	0.9
Modifid Penman*	7.31	0.8	7.49	0.8	7.40	0.7
Actual ETa	5.47		5.80		5.64	

(Growth scason of maize 110-120 days)
* (FAO No 24, 1977)
** (Smith 1991)

Table 6. Distribution of moisture (Percentage) extracted by the root for different Layer in 2004 and 2005 seasons

Season	2004 Depth of soil in cm				2005 Depth of soil in cm			
Irrigation regime	0-15	15-30	30-45	45-60	0-15	15-30	30-45	45-60
0.8	37.70	29.50	21.80	11.00	36.20	29.40	23.30	11.10
1.0	40.90	28.00	21.10	10.00	38.90	28.60	22.50	10.0
1.2	44.50	25.00	20.50	8.00	44.00	26.30	20.50	9.20
1.4	46.00	26.80	18.70	8.50	45.00	25.50	19.80	8.90

potassium fertilizer levels in 2004 and 2005 seasons. Results revealed that in both seasons extraction Percentage of water from the top soil (0-30cm) in 2004 and 2005 was 67.20, 68.20, 69.50, 72.80 and 65.60, 67.50, 70.30 and 71.30 for 0.8, 1.0, 1.2 and 1.4 (IW:CPE) ratio, respectively. The respective values for the subsurface layers (30-60 cm)in 2004 and 2005 were 32.80, 31.10, 28.50, 27.2 and 34.40, 32.50, 29.70 and 28.70 For the same irrigation regime, respectively.

Theses results indicated that most water extracted by plants was from the top soil (0.30 cm).

Furthermore the highest extraction percentages from the top. 30 cm Layer was recorded under 1.4 (IW: CPE) ratio in both seasons.

These results are in accordance with Those obtained by, Bennett and Doss (1960), Israelsen and Hansen (1962), EL- Marsafawy and Eid (1999) and Pandy *et . al.*(2000).

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جدولة ري محصول الذرة *(Zea Mays L.)* في منطقة مصر الوسطي

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أقيمت تجربتان حقليتان بمزرعة مركز البحوث الزراعية بالجيزة خلال موسمي ٢٠٠٤، ٢٠٠٥ وذلك بهدف دراسة تأثير الإجهاد الرطوبي ومواعيد الزراعة والتسميد البوتاسي علي محصول الذرة (هجين ثلاثي- أصفر٣٥٢) وذلك بهدف جدولة ري محصول الذرة في منطقة مصر الوسطي باستخدام وعاء البخر القياسي. من خلال أربع معاملات للبخر (١,٤، ١,٢، ١، ٠,٨) وثلاث معاملات لمواعيد الزراعة (١٥مايو، ٥يونيو، ٢٥ يونيو) ومعاملتين للتسميد البوتاسي (٢٤، ٣٦كجم بو٢ أ /للفدان).

أوضحت النتائج أن قيم الأستهلاك المائي لمحصول الذرة (هجين ثلاثي أصفر ٣٥٢) في منطقة الجيزة (مصر الوسطي) كانت.,٦٧٣، ٦٩٠,٧ملليمتر في الموسم الأول والثاني علي الترتيب وقد زادت قيم الاستهلاك المائي السنوي بزيادة عدد الريات (أي مع المعاملة ١,٤ معامل بخر الوعاء) كما زادت قيم الأستهلاك المائي مع المعاملة السمادية ٣٦كجم بو٢أ/ فدان. وقد سجل الاستهلاك المائي الشهري أعلي قيمة خلال شهر يوليو في كلا الموسمين لجميع المعاملات.

قدرت قيمة الاستهلاك المائي النظري باستخدام كل من معادلات بنمان المعدلة وبنمان مونتيث ودورينبوس ـ برويت حيث أوضحت النتائج تفوق معادلة دورينبوس ـ برويت يليها معادلتي بنمان المعدلة وبنمان مونتيث في حساب الأستهلاك المائي النظري لمحصول الذرة بمنطقة مصر الوسطي كما أوضحت النتائج لكلا الموسمين أن معظم الاستهلاك المائي كان من الطبقة السطحية (٠ – ٣٠سم) من التربة.