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IRRIGATION WATER SCHUDING DURING DIFFERENT GROWTH STAGES FOR MAIZE CROP

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ABSTRACT

Two field experiments were carried out for two summer seasons of 2010 and 2011 at Mallaway water Requirements Research station – El- Minia province Middle Egypt . The farm situated at 27̊ 9̄ latitude and 30̊ 5̄ longitude . Its altitude is about 44 m above mean sea level . The present research was carried out to study the effect of irrigation regime and plant population on actual water requirements, water use efficiency , crop coefficient , water saving , yield and economic evaluation for corn crop (20-30 single Hybrid) . On the other hand , this study aims to evaluate and to compare the potential evapotranspiration (ETP) equations and actual water requirements under El- Minia Governorate conditions , Also this study aims to observe the effect of water stress on the yield of corn crop to determine their optnum needs, and produce the highest yield with least possible amount of water The experiment include five treatments of irrigation regime and three levels of plant population . The irrigation regime treatments (A) were used as a_1 (control) traditional normal irrigation by farmer practices for all stages , a_2= irrigation at 90% of field capacity for all stages , a_3= skipping 3^{rd} irrigation at age (elongation stage) , a_4= skipping 5^{th} irrigation at age (flowering) stage , a_5= skipping 7^{th}irrigation at milk (ripeining) stage .

While the population densities were b_1 = 18,000 plants / fed (30 cm between hills) , b_2 = 24,000 plants / fed (25 cm between hills) , b_3= 30.000 plants / fed (20 cm between hills) . The treatments of irrigation regime were assigned to main plots . While , plant population were allocated in sub – plots . So that the experiment was arranged in a split –plot design .

The results indicated that the irrigation at 90% of field capacity for all growth stages gave the highest value of the grain yield in the two seasons 27.60 ardab per feddan . while the lowest mean values were 19.100 ardab per feddan was , obtained when skipping 5^{th} irrigation at flowering stage (A_4) in the two seasons .

Also , results indicated the total yield of corn crop increase by about 7.11% and 18.80 % under third population densities (b_3) compared to b_1 and b_2 respectively .

Results also indicate that irrigation regime A_2 (irrigation at 90% of field capacity for all stages) we cane save irrigation water by about 420.78 m3/fed. (11.28%) under El-Minia conditions , compared with the conventional irrigation by the farmers.

The results show also that the mean values of seasonal water consumptive use were 58.18 , 53.19 , 49.64, 49.50 and 49.05 cm/season for A_1, A_2 , A_3 , A_4, and A_5 respectively .

The average values of potential evapotranspiration (ET_p) by modified Blany & Criddle was nearest to general average values (+ 3.61%) while , the farthest values to general average were obtained by motifed Blaney and Pan evaporation method(-7.39and+5.88%), respectively (-7.39 and +5.88 %) , respectively .

Monthly potential evapotraspiration (ET_p) for Minia , province , Middle Egypt , was calculated using the modified Penman , modified Blaney & Criddle and pan method .

Average evaporation values of crop coefficient (Kc) calculated by many empirical formula for different treatments A_1 , A_2, A_3 , A_4 and A_5 were 0.56 , 0.50 , 0.46 , 0.47 and 0.48 respectively under first population density (b_1) . While these values , were 0.71, 0.63 , 0.57 , .60 and 0.63 . respectively under second population density (b_2) and 0.82 , 0.73 , 0.73 , 0.74 and 0.76 respectively under third population density (b_3). It could be noticed that the nearest values to average Kc which calculated by modified Blaney & Criddle while the farthest were by panevapration method.

In general it can be concluded that modified Blaney & Criddle nearest to actual water consumptive use followed by the modified pan evaporation method so we can recommend this equation (Modified Blaney & Criddle) for estimating ET_P in Minia region with the average crop coefficient due to the highest accruing for corn crop .

INTRODUCTION

Maize crop possesses the greatest biological potential among cereals to substaitially raise food production in the developing world . In Egypt , it is one the most important summer cereal crop , which considered as the main source of human consumption and among other of carbohydrates , oil and somewhat for protein and raw materials in many industries. The local consumption of corn had increased each year due to the continuous increase of population . It occupies about 2 million feddans annually produced about 5.6 million tons (Agric .Res.Center ,Maize Section)

The efforts of the government of Egypt in pushing hard to increase the production of maize in the last years to face the increasing demand of the mass .

A high yield of corn per unit area is the aim of agronomists and farmers under the limit of area and water resources . This goal can be achieved by a package of practices including optimum levels of several factors as application of improved agro- technique with using high yielding cultivars .

Among these factors , which affect on the growth and reproductive phase of maize are : plant population and irrigation regime which play a prominent role on maize productivity .The optimum levels of these factors varied widely according to different cultivars .

In arid and semi- arid regions like Egypt , where water resources are very limited , the maintenance of water resources is one of the most important national aims to face the great needs .

So , irrigation water management is very important nowdays in Egypt to determine the optimum water requirements and planning the irrigation regime with optimum plant population per area for obtaining maximum yield . More attention was paid to maintain the water resources by minimizing the losses , decreasing the water consumption and devoted farmers to schedule maize irrigation . Many investigators showed the effect of irrigation regime and plant population on yields , evapotranspiration and quality characteristics of corn crop in this connection , Israelsen and Hansen (1962) stated that when the soil is wet , most of moisture will be consumed from the soil surface

The reason is that roots normally grow in the surface. However , when the moisture of soil surface decrease more moisture is extracted from lower depths . The rate of transpiration is linear function of the soil moisture and added the evapotranspirtion rate increase to a peak and then diminishes as the crop matures . This peak of consumption of water comes at beginning of flowering and at end of the vegetative stage of growth . Rijtema (1966) pointed out that in order to calculate the evapotranspiration from certain crop The potential value must be multiplied by crop coefficient (K.c) . He also declared the methods calculate the potential evapotranspiriation and some of these methods or formulas gave reasonable accuracy under certain climatological conditions . Others methods agree only with the observed values of correction for log time and wind speed . Doorrenbos and Prut (1975) stated that Blaney – Criddle method may be used when temperature data were the only available measured weather data . They reported that the radiation method was more reliable than the presented Blaney & Criddle approach . In equatorial zone , on small island or at high altitudes , the radiation method might be more reliable even if measured sunshine or cloudless data were not available . Solar radiation maps were prepared for most locations in the world and they provided the necessary solar radiation data . He also pointed out crop water requirements are normally expressed by the rate of evapotranspiration (ET) in mm/ day or mm/ period. The level of ET has been shown to be related to evaporative demand off air which could be expressed as reference evapotranspiration and added calculated the crop evapotranspiration by using the following formula ETc= Kcx ETo.

Where :

ETc= Crop evapotranspiration

Kc=Crop coefficient .

ETo= Reference crop evapotranspiration

They added that the determination of crop coefficient (Kc) could be used as reference crop evapotranspiration (ETo) to maximum crop evapotranspiration when full water supply met water requirements of the crop Mahgoub (1979) mentioned that water stress caused no significant depression in ear length , number of rows / ear and number of grains / row . He also found that ear diameter and grain yield were significantly decreased by missing one irrigation during flowering and grain formation of maize . On the other hand , missing the 3^{rd} or 4^{th} or 5^{th} irrigation caused a reduction in grain yield by rates of 12.0 , 19.9 and 17.0 % , respectively . Sood et al. (1979) observed that increasing plant population from 40 to 60 and 80 thousand plants /ha increased grain yield /ha . Alemi (1981) pointed out that the maximum reduction in grain yield of maize was obtained when water stress occurred during the pollination or grain filling periods. Gouda (1982) pointed out that ear length , number of grains / row , 1000- kernel weight and grain yield / plant were decreased with increasing plant population , while grain yield / fed increased . On the other hand , ear diameter was not affected . El-Ashmoony (1983) stated that grain yield was increased with increasing plant population from 17.600 to 26.400 plants / fed , while 1000- kernel weight , ear length , ear diameter , number of rows/ ear and grain protein content were decreaeed . On the other hand , shelling percentage was not significantly affected by plant population . Ainer et al . (1986) found that yield and yield components of maize significantly reduced by skipping irrigation at vegetative and flowering growth stages . Semaika and Rady (1987) recommended any of modified Blaney & Criddle or the radiation formulad for estimating evapotranspiration of wheat , faba beans and clover for Giza area , Egypt , with the average crop coefficient due highest accuracy . Stansell et al. (1990) found that crop coefficient initially increased then decreased with the plant age , when pan evaporation method , under three soil moisture tension , was used . Abd-Alla (1991) showed that increasing density from 20.000 to 25.000 and 35.000 pkants /fed decreased plant height , stem diameter , number of green leaves / plants and leaf area / plant . Soliman et al. (1995) concluded that plant population densities had significant effect on ear diameter , ear length , number of kernels/ row and grain yield / plant. Increasing number of plants /fed from 20 to 30 thousand / fed increased . Esmail **(1996)** found that ear length , ear diameter , shelling percentage , 1000-kernel weight , grain yield / fed, crude protein percentage and oil percentage were significantly increased by decreasing irrigation intervals . On the other hand , number of rows / ear were not affected by irrigation intervals

Therefore , the objective of this work was to study the influence of irrigation regime and plant population on water applied , water consumptive use , water saving , crop coefficient and yield of corn crop .

MATERIALS AND METHODS

Two field experiments were carried out during two winter summer seasons of 2010 and 2011 at Mallawy, Water Requirements Research Station –El Minia Governorate ; Water Management Research Institute-National Water Research Center . The present research was carried out to study the effect of irrigation regime and population densities on water applied , water consumptive use , crop coefficient and yield of corn crop .

The experiments included five treatments of irrigation regime (A) and three population densities (B) with four replicated 25.5 that the experiment was arranged in a split plot design . irrigation treatments were

a_1 = (control) =traditionall irrigation by farmer practices for all stages , a_2 = irrigation at 90% of field capacity for all stages **,** a_3 = skipping 3^{rd} irrigation at age

(elongation stage) **,** a_4 = skipping 5^{th} irrigation at age flowering stage .

a_5 = skipping 7th irrigation at milk stage .

The population densities were b_1 =18,000 plants/fed (30cm between hills), b_2 24.000 plants/fed (25cm between hills), b_3= 30.000 plants /fed (20 cm between hills) .

Irrigation treatments were distributed randomly in the main plots .While population densities were distributed randomly in the sub- plots . Corn crop cultivar-namely *(20-30 single Hybrid)* was sown .Sub plots area are 30.0m^2 (each consisting of ten ridges and 60 cm wide , each had 5.0 meters long).

Soil analysis :

Soil analysis showed that the experimental soil was silt clay loam containing
(0.11 and 0.10 % of total N) , (11.8 and 11.0 ppm available P) , and (0.44 and 0.40 meq/100 g soil K) with pH 8.10 , in both studied seasons , respectively . Bulk density and field capacity are shown in Table (1) . Other agricultural practices required for growing corn crop were carried out as usually practiced in the region .

Table (1): Some soil –water characteristics for the experimental sites during the growing season at different depths in 2010 and 2011 seasons .

Depth (cm)	Average for two studied seasons		
		Field capacity **	
	Bulk density * g/cm^3	Cm	%
0-15	1.17	7.72	44.00
15-30	1.20	6.81	37.85
30-45	1.26	6.67	35.30
45-60	1.33	6.55	32.85
Average	1.24	37.5	37.50

*** Bulk density it was determined by using the undisturbed core samples according to Klute (1986) .**

**** Filed capacity (f.c%) it was determined by field method according to (Black ,1965) .**

Climatic condition :

Some metrological data during the two growing seasons are presented in Table 2 . These data were obtained from metrological Mallawy Station located at the ὁ 27 9ˉ latitude and 30 5ˉ longtiude and its altitude is about 44m above sea levels . These data are used to get potential evapotranspirnation in mm/ day by different empirical formula such as modified Panman , modified Blaney & Criddle and pan ebaporation method.

Recorded data :

Soil- water relations

Water Applied

In both growing seasons , water applied was measured by using a rectangular sharp crested weir. The discharge was calculated using the following formula :

$Q = CLH^{3/2}$ (Masoud, 1967**)**

Where:
Q : The discharge in cubic meters per second.
L : The length of the crest in meters.
H : The head in meters.
C : An empirical coefficient that must be determined from discharge measurements .

The quantity of water was measured in studied area (the farmer practices) by cut throat Flume size (20 x 90 cm) where applied water was added during each irrigation and at the end of each growth season the total quantity of water applied was estimated (m^3/ fed.)

$Q= Cs(Ha-Hb)^n / (-\log s)^{ns}$

Where
Q = Discharge in (m^3/Sec)
Ha = upstreamhead in meter
Hb=downstream head in meter
n= power found in table (free flow)
ns= its' value in table is submerged flow
S= the submergence ratio (Hb/Ha) as ratio
Cs= Coefficient of submergence flow

Water consumptive use (CU) :

The quantities of water consumptive use were calculated for the 60 cm soil depth which was assumed to be the depth of the effective root zone as reported by many investigators

Monthly and seasonal water effective consumptive use were calculated by the summation of water consumed for the different successive irrigation through the whole growing season (**Serry et al., 1980).**Calculation of CU was repeated for all irrigation until the harvesting .

Water consumptive use per feddan (4200m^2) can be obtained by the following equation .

$$CU= \frac{\theta_2 - \theta_1}{100} \times b.d \times \frac{depth}{100} \times area\ (4200 m^2)$$

which described by Israelsen and Hansen , (1962 **)**

Where :
CU= Amount of water consumptive use (m^3/ fed.) .
θ_2=Soil moisture content (% by weight) after irrigation .
θ_1=Soil moisture content (% by weight) before the next irrigation
b.d = Bulk density (g/ cm^3)
Potential evapotranspiration (ET_p)

Modified Penman equation:

ET_p=c [(W.Rn + 1-w) .f (u) .(ea-ed)] mm/day .

Table (2) : The average values of temperature degree (̊ C), relative humidity (%) , sunshine (hours/ day) , wind speed (km/ day) and evaporation rate (mm/day) for both growing seasons under studied .

Month	Temperature (̊ C)			Relative humidity (%)			Sunshine (hours/ day)	Wind speed Km/day	Evaporation (mm/ day)
	maximum	minimum	average	maximum	minimum	average			
June	35.77	20.94	28.35	75.54	22.4	48.97	12.63	231.23	13.10
July	36.10	20.91	28.50	67.03	23.97	45.5	11.30	196.41	12.40
August	36.13	21.1	28.61	71.89	28.1	49.99	12.10	138.38	10.95
September	35.1	19.6	27.35	74.57	27.63	51.10	10.90	142.84	8.76

Where :

$ET_{p=}$ Reference crop evapotranspiration in mm/ day .

W=Temperature –related weighting factor.

Rn=Net radiation in equivalent evaporation in mm/day.

f (u) =Wind-related function.

ed=Saturation vapour pressure of the air in (m bar).

ea= Mean actual vapour pressure of the air in (m bar)

=ea x RH mean /100 , in which , RH = relative humidity .

(ea-ed) =Difference between the saturation vapour pessue at mean air temperature and the mean actual vapour pressure of the air , both in mbar .

c=Adjustment factor to compensate for the effect of day and night weather conditions.

Modified Blaney & Criddle equation :

Blaney and Criddle (1955) observed that the amount of water consumptive used by crop during their growing seasons was closely correlated with means monthly temperature and day light hours .

ET_p = C [P 0.46T + 8.13)] mm/day .

Where :

ET_p= Potential evapotranspiration in mm/ day .

T= Mean daily temperature in C̊

P= Mean daily percentage of total annual daytime hours for given month and latitude .

C=Adjustment factor which depends on minimum relative humidity , sunshine hours and day time wind estimate .

Pan evaporation method :

Reference crop evapotranspiration (ET_p) can be obtained from the following equation :

ET_p=KP.E_{pan} (mm/ day) .

Where :

K_p= Pan coefficient depends on type of Pan , condition of Humidity , wind speed and pan coeficient (=0.75) .

Crop Coefficient (Kc)

Crop coefficient defined as the ratio between actual crop evapotranspiration (ET_a) and potential evapotranspirtaion (ET_p) when both are in a large fields , under optimum growing conditions *(FAO , 1977)* . In the experiment the following equation was applied to compute the Kc values .

Kc = ET_a /ET_p

Where :
Kc= Crop coefficient
ET_a= Actual evapotranspirtation (mm/ day) .
ET_p= potential evapotranspiration calculated by modified Penman (mm/ day)
Statistical analysis :

Data obtained from experimental treatments were subjected to statistical analysis and treatments means were compared using the L.S.D methods according to Snedecor and Cocharn (1980) .

RESULTS AND DISCUSSION

Grain yield / of maize

The average mean value of the grain yield ardab/fed. was significantly affected by irrigation treatment and plant population for corn crop in the two studied seasons .

Data in Table 3 showed that the differences between the average values of the grain yield ardebs per feddan were significantly effect by the irrigation treatment in the two studied seasons . Where data in Table 3 showed that the irrigation at 90% of field capacity for all stages gave the highest grain yield values in the two seasons which were 27.60 ardab per feddan . while the lowest mean values were 19.100 ardab per feddan , obtained when skipping 5^{th} irrigation at flower stage (A_4) in the two seasons . This might be expected since the average number of plants which carried more than one ear , ear length , ear weight , number of grain / row and grain yield /plant decreased by skipping irrigations during the flowering and maturity stages. It is clear from data in Table 3 that the drought stress might reduce translocation of assimilates from leaves , and as drought hasten maturation , this response in addition to reduce phosynthesis in the grain itself contribute to lower grain yield . These results agree with those obtained by *Mahgoub (1979) , Altemi (1981) , and Ainer et al (1986) , Esmail (1996) and Ainer et al 1986*

Concerning effect of plant population on the grain yield data showed that grain yield / ed , was significantly increase with increasing plant population densities from 18.000 to 30.000 plants / fed reaching heir maximum with density of 30.000 plant /fed in the two seasons . It is clear from the data in Table 3 the yield of corn crop increase by about 7.11% and 18.80% under third population densities (b_3) compored to b_1 and b_2 respectively .

Similar results were obtained by *Gouda (1982) , El- Ashmoony (1983) , Abd-Alla (1991) Soliman et al (1995)* , Sood et al (1979) mentioned that the increase in grain yield with increasing plant density were due to the increase in number of plants unit area . Therefore 25.000 , 30.000 plants / fed considered to be adequate to produce the highest grain yield .

Concerning the interaction between the two studied factors , data in Table 3 showed that the highest values were obtained from treatment which irrigated at90% of F.c for all stages under plant density b_3 (A_2b_3) where this treatment was the most superior treatment on this character (29.88 ardab/ fed.) in the both growing seasons .

Table (3) Average values of yield (ardab/ fed.) as affected by irrigation regime and plant density for corn crop during 2010 and 2011 seasons .

Irrigation regime (A)	(average both seasons)			
	Population densities (B)			
	b_1	b_2	b_3	Mean(A)
A_1	23.860	26.100	27.700	25.887
A_2	26.899	27.050	29.880	27.94
A_3	20.330	24.600	26.700	23.877
A_4	17.400	19.680	20.220	19.100
A_5	18.210	20.900	22.250	20.453
Mean (B)	21.340	23.666	25.350	23.45
LSD 5%	A **1.59	B **1.44	AB **2.49	

Where
A. Irrigation Treatments :
B. population Densities:
a_1 = (control) =Normal irrigation by farmer practices for all grow th stages .
b_1 =18.000 plants/fed (30cm between hills)
a_2 = irrigation until 90% of field capacity for all stages
b_2 24.000 plants/fed (25cm between hills)
a_3 = skipping 3rd irrigation at age (elongation stage) .
b_3= 30,000 plants /fed (20 cm between hills)
a_4 = skipping 5th irrigation at age (flowering stage) .
a_5 = skipping 7th irrigation at(milk ripe stage).

Seasonal irrigation water use (m3/fed.)

The amount of applied water in (m3/fed.) to different treatments are shown in Table 4 . It is clear from data obtained that water applied to corn crop plants were 3729.62 , 3308.84 , 3264.62 , 3249.10 and 3303.66 for A_1, A_2, A_3 , A_4 and A_5 respectively in the both studied seasons . Results also indicate that irrigation regime irrigation at 90% of field capacity for all growth stages) we cane save irrigation water by about 420.78 m3/fed (11.28%) under El-Minia conditions , compared with the common conventional irrigation by the farmers.

It could be concluded that the use of traditional irrigation regime by many farmers leads to use irrigation water with high rates than the recommended rates, that leads to negative effect on the environment soil , fertilizer , and ground water in the long term . So these results reflest how much of irrigation water can be saved when using the reasonable irrigation treatments .

So the use of regime irrigation becomes very important to save water . The best irrigation regime should give favorable crop yield and optimum use of water and so estimating economic of irrigation water becomes very important of planning to irrigation management project where the over irrigation practiced by the farmers usually leads to low irrigation efficiency , water logging and high losses of water and fertilizer so the proper water management not only accurate determination of crop water requirements but also helps to know how , when and how much water should be applied to get high irrigation efficiency of each unit of water applied .

Daily, monthly and seasonal actual water consumptive use :

Daily and monthly actual water consumptive use values were presented in Table 5 and 6 . The data obtained indicated that daily water consumptive use increased gradually until reached its maximum values in flowering season and milk stage in both seasons which is considered the critical stage period in water demands of corn crop . Then , it decline by the end of growing season. These result are in hence increases in transplanting . Regarding the effect of population densities the results indicated that the highest values of average water consumptive use (63.00 cm/ seasons) was obtained from b3(30.000 plants /fed.) while thee lowest value of water consumptive use was obtained from b1(18,000 plants /fed.) .It is obvious from data increasing plant population from 18.000 to 30000 plants /fed. Increase water consumptive use in both seasons .

Table (4) : Average amount of water applied m3/fed (monthly and seasonal) . for maize crop in both studied seasons .

Treatments	Water applied (m3/fed)								
	First irrigation	**Second irrigation**	**Third irrigation**	**Fourth irrigation**	**Fifth Irrigation**	**Sixth Irrigation**	**seventh irrigation**	**Eight irrigation**	**Total (m^3/season)**
A1	580.85	435.63	465.00	475.55	480.52	455.25	425.90	410.90	3729.62
A2	509.61	378.45	405.54	425.80	430.50	400.50	380.22	378.22	3308.84
A3	580.80	435.65	-	475.55	480.52	455.25	425.90	410.90	3264.57
A4	580.80	435.65	465.00	475.55	-	455.25	425.90	410.90	3249. 05
A5	580.80	435.65	465.00	475.55	480.52	455.25	-	410.90	3303.67
Average									

*** Source : Actual field measurements**

Where :

A. Irrigation Treatments :

a_1 = (control) =Nor traditional irrigation by farmer practices for all growth stages .

a_2 = irrigation at 90% of field capacity for all stages

5-6

Table (7) Average of seasonal actual water consumptive use (m3/fed.) for corn plants as affected by irrigation regime and population densities in both studied seasons .

Irrigation Treatments	Seasonal actual water consumptive use (cm/season)			
	Population densities			
	b_1	b_2	b_3	Average
A_1	47.20	58.92	68.42	58.18
A_2	43.03	52.99	63.54	53.19
A^3	38.57	48.68	61.66	49.64
A_4	39.05	48.95	60.50	49.50
A_5	40.02	49.98	60.89	50.30
Average	41.57	51.90	63.00	

Potential evapotranspiration (ET_p) :

Data in Table 8 show that the computed values of daily , monthly and seasonal potential evapotranspiration (mm/ day,mm/ month and mm/ season respectively) according to modified Penman , modified Balney & Criddle and pan evaporation method for two studied seasons . It can be observed from data in Table 8 that the lowest value of ET_P (72.28 cm/season) was obtained from modified Pan man . While , the highest average ETP (81.74 and 77.64 cm/season) were obtained by Pan evaporation method modified Blany & Criddle during both studied seasons respectively . In general it can be concluded that the actual values of evapotranspiration values were less than its values computed by climatologically equations . This due to the estimated factors in these equations . Results in Table 8 show also that the average values of potential evapotransperation (ET_p) by modified Blany & Criddle was nearest to general average values (+ 3.61%) while , the farthest values to general average were obtained by motifed Blanoy and Pan evaporation method about (- 7.39 and +5.88 %) , respectively .

It could be noticed that the nearest ET_P values to the average are those which are obtained form Blany & Criddle while , the farthest obtained from the modified penman and Pan evaporation method .These results are in agreement with those obtained by Doorenbos and Pruitt (1975).

Table (8):Average computer daily, monthly, seasonal potential evapotranspiration) (ET_p) (mm) in and deviation percentage during both studied seasons .

Empirical formula	June		July		August		September		Total		Deviation percentage (%)
	Daily (mm)	Monthly (mm)	Daily (mm)	Monthly (mm)	Daily (mm)	Monthly (mm)	Daily (mm)	Monthly (mm)	mm /season	cm /season	
Modified Penman	8.20	114.80	7.40	229.40	6.60	204.60	5.80	174.00	722.8	72.28	-6.39%
Modified Blaney & Criddle	8.97	125.58	8.12	201.72	7.14	243.04	6.87	206.10	776.44	77.64	+0.55%
Pan evaporation method	9.82	137.48	9.30	228.30	8.21	254.51	6.57	197.10	817.39	81.74	+5.85%
Average	8.99	125.95	8.27	219.81	7.32	324.5	6.41	192.40	**772.21**	**77.22**	

Crop coefficient (Kc) :

Effect of crop characteristics on crop water requirement was indicated by the crop coefficient (Kc) which represent the relationship between reference potential (ET_p) and actual crop evapotranspiration (ETa)

Data of crop coefficient for sugar corn crop for each treatment calculated using the actual consumptive use (ETa) and potential evapotranspiration (ETp) (Kc= ET_a /ETp) using the modified Penman , modified Blaney & Criddle and pan evaporation method .

The values of Kc for different treatments are shown in Tables 9 ,10 and 11 .It is clear that the values of Kc show slight increase with time after planting till reached their peak in February (formation of ear) and then decreased at the end of growth season.

Results show also that the average values of crop coefficient (Kc) calculated by many empirical formula for different treatments A_1 , A_2, A_3 , A_4 and A_5 were 0.56 , 0.50 , 0.46 , 0.47 and 0.48 respectively under first population density (b_1) . While , were 0.71, 0.63 , 0.57 , .60 and 0.63 . respectively under second population density (b_2) while, 0.82 , 0.73 , 0.73 , 0.74 and 0.76 respectively under third population density (b_3). It could be noticed that the nearest values to average Kc which calculated by modified Blaney & Criddle while the farthest were by pan evaporation method .

Comparison between the actual water consumptive use and calculated evapotrans piration (cm/season)

The calculated evapotranspiration ($ET_{cal.}$) mm/ month, mm/ season and cm /season) are shown in Tables 12 ,13 and 14 for different treatments using the relation $ET_{cal.}$= Kc average X ET_p and its comparison with actual consumptive use (ET_a) for different treatments in Figures 1 and 2 .

Data in Figures 1 and indicated that calculated evaportanspiration (ET_{cal}) by modified Blaney & Criddle nearest to actual water consumptive use followed by the modified Panman and panevaporation method so it can be recommend this equation (Modified Blaney & Criddle) for estimating ET_P in Minia region with the average crop coefficient due to the highest accruing for Corn crop .These results are in agreement with those reported by Rijtema (1966) , Doorenhbos and Pruit (1975).

F1

F2

9-10-11.

Table (12) : The Average calculated monthly evapotranspiration (Kc average x ETp) mm / month , mm / season and cm / season for different irrigation treatments (under the first population density b_1) for corn crop in the two studied season .

		June	July	Agust	Sept	Total	
						mm	cm
A_1b_1	Modified Panman	59.70	149	163.70	48.72	421.22	42.12
	Modified Blaney &Criddle	65.30	163.62	194.40	57.70	481.02	48.10
	Pan method	71.50	187.39	203.90	55.20	517.99	51.79
Average		64.83	166.34	187.33	53.87	473.41	47.34
A_2b_1	Modified Panman	48.26	133.05	143.22	66.12	390.95	39.09
	Modified Blaney &Criddle	52.71	145.99	170.12	78.31	447.16	47.72
	Pan method	53.54	167.20	178.40	74.89	473.83	47.38
Average		51.50	148.75	163.91	73.12	437.31	43.71
A_3b_1	Modified Panman	44.77	123.87	132.99	43.50	345.13	34.51
	Modified Blaney &Criddle	48.60	135.90	13592	51.52	373.24	37.22
	Pan method	53.62	155.68	165.63	49.27	424.20	42.42
Average		48.99	138.48	144.85	48.10	380.80	38.08
A_4b_1	Modified Panman	55.10	135.35	110.50	48.72	349.67	34.96
	Modified Blaney &Criddle	60.27	148.52	148.50	57.70	44.99	41.49
	Pan method	65.99	170.10	137.43	55.18	428.70	42.87
Average		60.45	151.32	132.14	53.87	397.78	39.78
A_5b_1	Modified Panman	56.215	116.99	128.89	53.94	356.07	35.61
	Modified Blaney &Criddle	61.15	128.39	153.10	63.89	406.53	40.65
	Pan method	67.36	147.03	160.34	61.60	435.83	43.58
Average		61.65	130.8	147.44	59.81	399.48	39.95

Table (13):The Average calculated monthly evapotranspiration (Kc average x ETp) mm / month,mm/season and cm/season for different irrigation treatments (under the second population density b_2) for corn crop in the two studied season .

		June	July	Agust	Sept	Total	
						mm	cm
A_1b_2	Modified Panman	71.18	174.30	202.25	76.60	524.63	52.45
	Modified Blaney &Criddle	77.85	191.30	240.69	90.68	600.43	60.04
	Pan method	85.23	219.10	252.30	86.74	643.37	64.34
Average		78.09	194.90	231.75	84.67	589.48	58.94
A_2b_2	Modified Panman	65.43	155.99	188.23	62.64	472.29	47.23
	Modified Blaney &Criddle	71.58	146.89	223.59	74.20	516.06	51.61
	Pan method	78.36	196.04	234.44	70.95	579.79	57.98
Average		71.79	166.24	215.42	69.26	522.68	52.27
A_3b_2	Modified Panman	59.69	130.75	171.86	60.90	433.20	43.32
	Modified Blaney &Criddle	65.30	143.50	204.15	72.13	485.01	48.50
	Pan method	72.50	164.33	214.05	68.98	518.86	51.88
Average		65.83	146.19	196.69	67.34	479.02	47.9
A_4b_2	Modified Panman	79.21	160.38	137.08	62.64	439.51	43.95
	Modified Blaney &Criddle	86.60	176.20	162.83	74.19	499.87	49.98
	Pan method	94.86	201.81	170.52	70.96	538.10	53.81
Average		86.89	179.53	156.81	69.26	492.49	49.24
A_5b_2	Modified Panman	78.06	174.43	176.77	48.72	477.89	47.79
	Modified Blaney &Criddle	85.39	191.30	199.30	57.71	533.7	53.37
	Pan method	93.49	219.10	208.69	55.9	576.47	57.64
Average		85.60	194.94	194.92	54.11	529.35	52.93

Table (14) : The Average calculated monthly evapotranspiration (Kc average x ETp) mm / month , mm / season and cm / season for different irrigation treatments (under the third population density b_3) for corn crop in the two studied season .

		June	July	Agust	Sept	Total	
						mm	cm
A_1b_3	Modified Panman	79.21	197.28	232.74	100.92	61064	61.06
	Modified Blaney &Criddle	23.86	216.47	277.06	119.54	636.89	63.69
	Pan method	94.86	247.93	290.50	114.32	747.59	74.67
Average		65.98	220.56	266.77	111.59	665.04	66.50
A_2b_3	Modified Panman	76.92	183.52	194.37	88.74	546.55	54.35
	Modified Blaney &Criddle	84.14	201.37	230.89	105.11	621.49	62.15
	Pan method	92.11	230.64	280.10	100.52	703.37	70.34
Average		84.39	205.18	235.12	98.12	623.81	62.28
A_3b_3	Modified Panman	74.62	142.23	182.09	92.22	491.15	49.11
	Modified Blaney &Criddle	81.63	156.07	216.30	109.23	563.22	56.32
	Pan method	89.36	141.54	226.79	104.46	562.15	56.21
Average		81.88	146.61	208.39	101.97	538.84	53.88
A_4b_3	Modified Panman	91.84	192.69	163.68	93.96	542.17	54.22
	Modified Blaney &Criddle	100.46	211.46	194.43	111.29	617.64	61.76
	Pan method	109.98	242.17	203.61	106.40	662.15	66.21
Average		100.76	215.44	187.24	103.88	607.32	60.73
A_5b_3	Modified Panman	97.58	192.96	186.18	80.04	556.49	56.65
	Modified Blaney &Criddle	106.74	211.44	211.17	94.81	624.16	60.02
	Pan method	116.85	242.17	231.60	90.66	681.28	68.13
Average		107.06	215.52	209.65	88.50	620.64	61.59

CONCLUSION

The obtained results indicated that maize plants of (20-30 signal Hybrid) con irrigate at 90% of F.C for all growth stages and population density b_3 |(30,000 plants / fed.) to produce the highest yield with less possible amount of applied water applied . On the other had this study indicated that the average values of potential evapotranspiration (ET_{cal}) by modified Blaney & Criddle was nearest to actual water consumptive use for corn crop so , it can be recommend modified Blaney & Criddle for calculating the potential evapotranspiration for maize crop under El-Minia conditions

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جدولة مياة الرى خلال مراحل النمو المختلفة لمحصول الذرة الشامية

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معهد بحوث ادارة المياه المركز القومى لبحوث المياه

اجريت هذه التجربه خلال الموسم الصيفى لعامى 2010 / 2011 م بمحطة المقننات المائية بملوي-المركز القومي لبحوث المياه بمحافظة المنيا – مصر الوسطى ومنطقة البحث تقع عند تلاقى خط عرض 9ˉ 27˚ شمالا وخط طول50ˉ30˚ شرقاً وترتفع بمقدار 44 متر عن سطح البحر وتهدف هذه الدراسة الى تأثير أسلوب الرى والكثافة النباتية على الاحتياجات المائية الفعلية لمحصول الذرة الشامية – الاستهلاك المائى الفعلى – معامل المحصول – انتاجية المحصول بالاضافة الى تقييم طرق قياس الاستهلاك المائى النظرى المحسوب من المعادلات المناخية (معادلة بنمان المعدلة – بلانى وكرديل المعدلة – وعاء البخر القياسي) وذلك بالمقارنة بالاحتياجات المائية الفعلية للمحصول تحت الظروف الجوية لمحافظة المنيا والمناطق المماثلة لها فى الظروف الجوية وقد اشتملت التجربة على خمس معاملات لاسلوب اضافه المياه وهى :

A_1 (control) الرى التقليدب بمعرفة المزارع لجميع مراحل نمو النبات ، A_2 اضافه المياه حتى 90% من السعة الحقلية لجميع مراحل نمو النبات ، A_3 الرى الطبيعى مع اسقاط الرية خلال مرحلة الاستطالة والانبات ، A_4 الرى الطبيعى مع اسقاط رية خلال فترة التزهير ، A_5 الرى الطبيعى مع اسقاط رية خلال فترة الطور العجينى وتكوين الحبوب .

وكذلك اشتملت التجربة على ثلاثه معاملات منشقة للكثافة النباتية وهى b_1 (18000 نبات للفدان بمسافة 30 سم بين الجور) ، b_2 (24000 نبات للفدان بمسافة 25 سم بين الجور) ، b_3 (30000 نبات للفدان بمسافة 20 سم بين الجور) لذا صممت التجربة في قطع منشقة مرة واحدة spilt –plot ويمكن تلخيص **النتائج المتحصل عليها كما يلي:-**

1-كان متوسط الاستهلاك المائى الفعلى للمحصول بمقدار 58.18 ، 53.19 ، 49.64 ، 49.50 ، 49.05 سم/ موسم للمعاملات A_5,A_4,A_3, A_2,A_1 على التوالى تحت جميع المستويات المختلفة للكثافة النباتية .

2-أوضحت النتائج بأن هناك تأثيراً معنوياً للكثافة النباتية على معدل الاستهلاك المائى الفعلى للنبات حيث يزداد الاستهلاك المائى كلما زادت الكثافة النباتية .

3- ادت الزراعة بالكثافة النباتية b_3الى زيادة فى الانتاجية بنحو 7.11 % ، 18.80% مقارنة بالكثافات الاخرى b_1b_2 على التوالى .

4- اعطيت المعاملة الثانية A_2 تحت جميع المستويات المختلفة للكثافات النباتية اعلى انتاجية من الحبوب حيث كانت بمقدار 27.610 أردب للفدان يليها المعاملة التقليديه بمعرفة المزارع A_1 حيث كانت بمقدار

25.887 أردب للفدان بينما أعطت المعاملة الرابعة (الرى الطبيعى مع اسقاط رية خلال مرحلة التزهير) اقل انتاجية 19.100 أردب للفدان .

5- كانت القيم المحسوبه للاستهلاك المائى النظرى (ET_P) بواسطة معادله بلانى وكرديدل المعدلة أقرب المعادلات الى المتوسط العام بانحراف قياسى قدره +55 , % بينما كانت القيم المحسوبه للاستهلاك المائى النظرى بواسطة وعاء البخر ومعادله بنمان المعدله أبعد المعادلات عن المتوسط العام بانحراف قياسى قدره – 6.39 % ، + 5.85 % على التوالى .

6- أدت المعاملة الثانية A_2 (الى اضافة المياه حتى 90% من السعة الحقلية لجميع مراحل نمو النبات) الى الحصول على وفر مائى بنسبة 11.28 % بما يوازى (420.87 م3 للفدان) وذلك بالمقارنة باسلوب الرى التقليدى السائد بالمنطقة .

7-أوضحت النتائج أن متوسط قيمة معامل المحصول الموسمى المحسوب للمعادلات المناخية المختلفة للمعاملات الرئيسية A_5,A_4,A_3,A_2,A_1 كانت بمقدار 56 , ، 50 , ، 46 ، 47 , ، 45 , على التوالى تحت الكثافة النباتية b_1 على التوالى بينما كانت بمقدار 71, ، 63 , ، 57 , ، 60, ، 63, على التوالى تحت الكثافة النباتية b_2 على التوالى وكانت بمقدار 82, ، 73 ، 73, ، 74 , ، 76 , لنفس المعاملات السابقة تحت الكثافة النباتية b_3 على التوالى .

8-كانت القيم المتحصل عليها للاستهلاك المائى النظرى المحسوب باستخدام المعادلة ($Kc = (ET_{cal}$ average x ET_p) والمحسوبة باستخدام معادلة بلانى وكرديل المعدلة أقرب القيم الى الاستهلاك المائى الفعلى لمحصول الذرة الشامية بينما أعطت معادلتى حوض التبخر وبنمان المعدلة أبعد القيم عن الاستهلاك المائى الفعلى ومن ثم توصى الدراسة باستخدام معادلة بلانى وكرديل المعدلة وذلك عند تقدير الاستهلاك المائى لمحصول الذرة الشامية تحت ظروف محافظة المنيا والمناطق المماثلة لها فى الظروف الجوية .

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Table (5): Average actual water consumptive use values (daily , monthly and seasonal) for maizecrop plants as affected by irrigation regime and plants density in both studied seasons 2010 and 2011

month	A_1								
	b_1			b_2			b_3		
June	4.71	6.60	277.20	5.82	8.15	342.30	6.22	8.71	365.82
July	5.30	16.43	490.06	6.25	19.37	813.54	7.10	22.01	624.42
August	6.02	18.67	784.14	7.42	23.00	966.00	8.55	26.5	1113
September	1.83	5.50	231	2.8	8.40	352.8	3.73	11.20	470.4
Total		47.2	1982.4		58.92	2474.64		68.42	2873.64

month	A_2								
	b_1			b_2			b_3		
June	4.32	6.05	254.10	5.15	7.12	302.82	6.50	9.10	382.20
July	4.82	14.94	627.48	5.65	17.51	735.42	6.57	20.36	855.12
August	5.26	16.31	685.02	6.90	21.4	898.80	7.64	23.68	994.56
September	1.91	5.73	240.66	2.32	6.96	292.32	3.24	10.04	436.8
Total		43.03	18070.26		52.99	2220.58		63.54	2668.68

month	A_3								
	b_1			b_2			b_3		
June	3.53	4.94	207.48	4.72	6.61	277.62	6.42	8.99	337.58
July	4.45	13.79	579.18	4.68	14.51	6.09.42	5.76	17.86	750.12
August	4.89	15.16	636.72	6.33	19.63	824.44	7.31	22.66	921.72
September	1.56	4.68	196.56	2.98	8.94	375.48	4.05	12.15	510.03
Total		38.57	1619.94		48.68	2044.98		61.66	2516.64

Table (6) :Average actual water consumptive use values (daily , monthly and seasonal) for corn crop plants as affected by irrigation regime and plants density in both studied seasons 2010 and 2011 .

month	A_4								
	b_1			b_2			b_3		
June	4.36	6.10	226.2	6.18	8.65	363.30	7.22	10.10	242.20
July	4.81	14.91	626.22	5.77	17.90	751.80	6.89	21.36	897.12
August	4.00	12.43	522.06	5.00	15.50	630.00	5.98	18.54	778.68
September	1.87	5.61	235.62	2.3	6.90	289.80	3.50	10.50	441
Total		39.05	1640.910		48.95	2055.90		60.50	2541

month	A_5								
	b_1			b_2			b_3		
June	4.36	6.10	256.20	6.11	8.55	359.10	7.42	10.40	436.80
July	4.24	13.14	551.88	5.67	17.57	737.94	6.58	20.39	856.38
August	4.68	14.81	622.02	5.93	18.40	722.80	6.84	21.20	890.40
September	1.99	5.98	250.74	1.82	5.46	229.32	2.97	8.90	373.8
Total		40.02	1680.84		49.98	2099.16		60.89	2557.38

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Table (9):The crop coefficient (Kc= ET_a /ET_p) for different treatments for corn crop (under the first population density b_1) in both studied seasons.

Treatments Month	A_1b_1				A_2b_1				A_3b_1				A_4b_1				A_5b_1			
	Kc				Kc				Kc				Kc				Kc			
	Modifieied panman	Modified Blaney & Criddle	Pan me thod	(kc) Average	Modifieied panman	Modified Blaney & Criddle	Pan method	(kc) Ave rage	Modifieied panman	Modified Blaney & Criddle	Pan method	(kc) Ave rage	Modifieied panman	Modified Blaney & Criddle	Pan method	(kc) Ave rage	Modifieied panman	Modified Blaney & Criddle	Pan method	(kc) Averag e
June	0.57	0.52	0.48	0.52	0.53	0.48	0.44	0.42	0.43	0.39	0.35	0.39	0.51	0.49	0.44	0.48	0.53	0.49	0.44	0.49
July	0.72	0.65	0.57	0.65	0.65	0.59	0.52	0.58	0.60	0.55	0.48	0.54	0.65	0.59	0.52	0.59	0.57	0.52	0.45	0.51
August	0.91	0.70	0.73	0.80	0.79	0.67	0.64	0.70	0.73	0.62	0.59	0.65	0.61	0.51	0.49	0.54	0.72	0.61	0.58	0.63
September	0.31	0.27	0.27	0.28	0.33	0.28	0.29	0.30	0.27	0.23	0.24	0.25	0.32	0.27	0.25	0.28	0.34	0.29	0.30	0.31
Total	0.62	0.55	0.51	0.56	0.57	0.50	0.47	0.50	0.51	0.45	0.41	0.46	0.52	0.46	0.42	0.47	0.54	0.48	0.44	0.48

Table (10): The crop coefficient (Kc= ET_a /ET_p) for different treatments for corn crop (under the second population density b_2) in both studied seasons.

Treatments Month	**A_1b_2**				**A_2b_2**				**A_3b_2**				**A_4b_2**				**A_5b_2**			
	Kc				**Kc**				**Kc**				**Kc**				**Kc**			
	Modifieied panman	**Modified Blaney & Criddle**	**Pan method**	**(kc) Average**	**Modifieied panman**	**Modified Blaney & Criddle**	**Pan method**	**(kc) Average**	**Modifieied panman**	**Modified Blaney & Criddle**	**Pan method**	**(kc) Average**	**Modifieied panman**	**Modified Blaney & Criddle**	**Pan method**	**(kc) Average**	**Modifieied panman**	**Modified Blaney & Criddle**	**Pan method**	**(kc) Average**
June	0.63	0.65	0.59	0.62	0.62	0.57	0.52	0.57	0.57	0.52	0.48	0.52	0.75	0.69	0.63	0.69	0.74	0.68	0.62	0.68
July	0.84	0.77	0.76	0.76	0.76	0.69	0.61	0.68	0.63	0.57	0.50	0.51	0.77	0.71	0.62	0.70	0.70	0.91	0.61	0.76
August	1.12	0.95	0.90	0.99	1.04	0.88	0.84	0.92	0.96	0.80	0.77	0.84	0.67	0.63	0.61	0.67	0.97	0.84	0.72	0.82
September	**0.48**	**0.41**	**0.43**	**0.44**	**0.40**	**0.34**	**0.35**	**0.36**	**0.39**	**0.33**	**0.34**	**0.35**	**0.40**	**0.33**	**0.35**	**0.36**	**0.31**	**0.26**	**0.28**	**0.28**
Average	**0.76**	**0.69**	**0.67**	**0.71**	**0.70**	**0.62**	**0.58**	**0.63**	**0.64**	**0.55**	**0.52**	**0.57**	**0.67**	**0.59**	**0.55**	**0.60**	**0.68**	**0.67**	**0.56**	**0.63**

Table (11): The crop coefficient (Kc= ET_a /ET_p) for different treatments for corn crop (under the third population density b_3) in both studied seasons.

Treatments month	A_1b_3				A_2b_3				A_3b_3				A_4b_3				A_5b_3			
	Kc				Kc				Kc				Kc				Kc			
	Modifieied panman	Modified Blaney &	Pan method	(kc) Average	Modifieied panman	Modified Blaney &	Pan method	(kc)Average	Modifieied panman	Modified Blaney & Criddle	Pan method	(kc) Average	Modifieied panman	Modified Blaney & Criddle	Pan method	(kc) Average	Modifieied panman	Modified Blaney & Criddle	Pan method	(kc) Average
June	0.75	0.69	0.63	0.69	0.73	0.68	0.61	0.67	0.78	0.71	0.65	0.71	0.88	0.80	0.73	0.80	0.90	0.91	0.75	0.85
July	0.96	0.87	0.76	0.86	0.89	0.81	0.71	0.80	0.78	0.71	0.62	0.70	0.93	0.84	0.74	0.84	0.89	0.91	0.71	0.84
August	1.29	1.09	1.04	1.14	1.15	0.79	0.93	0.95	1.11	0.93	0.89	0.98	0.91	0.76	0.73	0.80	1.04	0.87	0.83	0.91
Septemper	0.64	0.54	0.57	0.58	0.56	0.47	0.49	0.51	0.59	0.51	0.53	0.54	0.60	0.51	0.53	0.54	0.51	0.43	0.45	0.46
Average	0.91	0.79	0.75	0.82	0.83	0.68	0.68	0.73	0.81	0.71	0.67	0.73	0.83	0.73	0.68	0.74	0.83	0.78	0.68	0.76

Fig (2) : Comparision Between the actual consumptive use (cm/season for two seasons)and calculated evapotranspiration (cm/season for both seasons)for different irrigation treatments for corn crop(under the Second population density b2)

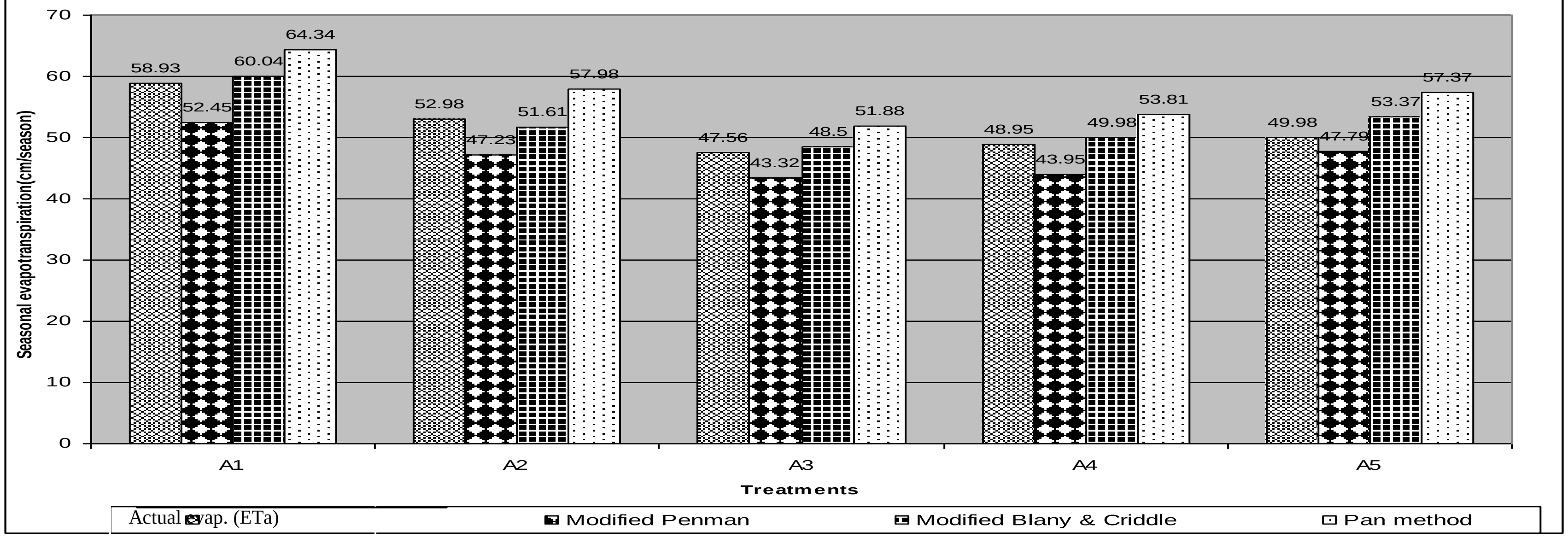

Fig (3) : Comparision Between the actual consumptive use (cm/season for two seasons)and calculated evapotranspiration (cm/season for both seasons)for different irrigation treatments for corn crop(under the Third population density b3)