*J. Agric. Sci. Mansoura Univ., 31 (2): 1185 - 1199, 2006*

# WATER MANAGEMENT OF MAIZE CROP ON NORTH DELTA

**Meleha, M.I.**
**Water Management and Irrigation Systems Research Institute, National Water Research Center Cairo, Egypt.**

## ABSTRACT

Water management has become a crucial issue particularly in arid and semi arid zones that are characterized by scarce, or limited, water resources. Egypt is no exception from other countries that lie in these zones. Unless strict measures are taken to maintain sustainability of irrigation, we will face a water problem in the near future. It is therefore deemed necessary that Egypt find out ways, and techniques to develop, control, manage, and use their water resources more efficiently in order to meet the growing demand for water.

Two field experiments were carried out during summer seasons of 2002 and 2003 to study the effect of irrigation in two directions and cut back stream on maize yield and water saving at El Karada water requirement, Research station, Kafer El Sheik Governorate, Water Management and Irrigation Systems Research Institute, National Water Research. The treatments of irrigation in two-direction and cut back stream when water reached the end and 90% of the furrow was the best individual or combination treatments for obtaining maximum grain yield results indicated that

- water could be saved as an average of 268.64 $m^3$/fed (9.66%), 567.45 $m^3$/fed, (20.54 %) and 778. $m^3$/fed. (28.18%) with applying irrigation water under cut back stream when water reached the 90%, 80% and 70% of the furrow length respectively.
- The water consumptive use increased as the applied irrigation water increased.
- Irrigation application efficiency and water utilization were the highest using irrigation in two directions and cut back stream when water reached 7o% of the furrow length, while the highest crop water use efficiency was found with cut back stream when water reached 80% of the furrow length.
- The maximum values of total income, total return, water productivity and economic efficiency obtained from plants grown under irrigation in two directions with cut back stream when water reached 90% of the furrow length.

Results help to suggest that using cut back stream when water reached 90 % of the furrow length can save water irrigation with amount of (268.64 $m^3$/fed.) 15.513960 million $m^3$/area (57750 feddan) under Kafer El sheikh conditions. These quantities of saving water enough to cultivate area of about 5601.97 feddans under kafer el shiekh conditions

## INTRODUCTION

Water management has become a crucial issue particularly in arid and semi arid Zones that are characterized by scarce or limited, water resources. Egypt is no exception from other countries that lie in these zones. Unless strict measures are taken to maintain sustainability of irrigated lands lands in the near future. It is therefore deemed necessary that Egypt find out ways., and techniques to develop, control, manage, and use their water resources more efficiently in order to meet the growing demand of water. Bassett and Evans (1983) pointed that the excessive cut back during the post-advance phase impairs uniformity at the tail of the field. Abdel- Maksoud and Khater (1997) studied the effect of alternate furrow irrigation on some soil water relations and yield for cotton and maize. The discharge average was 6 L 15. They reported that, applying the water to either cotton or maize crops through the other-row technique tended to reduce the total water applied for cotton and maize crops comparable to the traditional irrigation method. El-Sherbeny et al (1997). revealed that alternate furrow method saved about 22,28% of irrigation water. The water application efficiency of alternate method were higher than traditional method. They added that soil water movement in lateral directions were higher than in vertical directions under alternate furrow method and vise versa for traditional furrow method. Morsi (2001) stated that surge-alternative method saved water about 15.45 % and 35.95% per season compared with alternative and continuous methods, respectively. The aim of this study was to investigate the effect of irrigation in two directions and cut back stream on productivity of maize, water saving and water use efficiency.

## MATERIALS AND METHODS

Two field experiments were carried out during summer seasons of 2002 and 2003 at El Karda research station, Kafer el Sheik Governorate, water management and irrigation system research institute, National water research center, Kafer el Sheikh to study the effect of irrigation in two directions (one and two directions) and cut back stream when water advanced to distance of 100, 90, 80 and 70 % of the length of furrows (80m), on maize yield and water saving. The experimental design was split-plots with four replicates figure (1). The irrigation in two directions treatments occupied main plots and the cut back stream treatments occupied the sub plots. The Physical and Chemical properties of the soil were analyzed according to black (1995) and presented in Tables 1 & 2 respectively. The depth of the ground water table ranged between 90 and 120 cm during the two experiments.

**Table (1): Some physical properties of the experiment soil**

| Soil depth, cm | Particle size distribution | | | Soil texture | B.d., g/cm$^3$ | F.c % w/w | Wp % w/w |
|---|---|---|---|---|---|---|---|
| | Clay % | Silt % | Sand% | | | | |
| 0-20 | 62.91 | 21.5 | 15.59 | Clayey | 1.05 | 44.5 | 24.20 |
| 20-40 | 56.90 | 25.38 | 17.72 | Clayey | 1.19 | 40.0 | 21.80 |
| 40-60 | 52.20 | 26.17 | 21.63 | Clayey | 1.25 | 36.00 | 18.90 |

**Table (2): Some chemical properties of the experiment soil.**

| depth, cm | PH | EC, dS/m | Soluble Cations (Meq/l) | | | | Soluble anions (Meq/l) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | $Ca^{++}$ | $Mg^{++}$ | $Na^{+}$ | $K^{+}$ | $Cl^{-}$ | $Co_3^{-}$ | $Hco_3^{-}$ | $So_4^{--}$ |
| 0-20 | 8.3 | 2.0 | 5.5 | 5.0 | 9.2 | 0.75 | 6.4 | - | 9.0 | 5.05 |
| 20-40 | 8.3 | 2.10 | 5.8 | 5.30 | 9.4 | 0.75 | 6.9 | - | 9.0 | 5.35 |
| 40-60 | 8.3 | 2.65 | 6.8 | 5.9 | 15.5 | 0.90 | 12 | - | 11.0 | 6.10 |

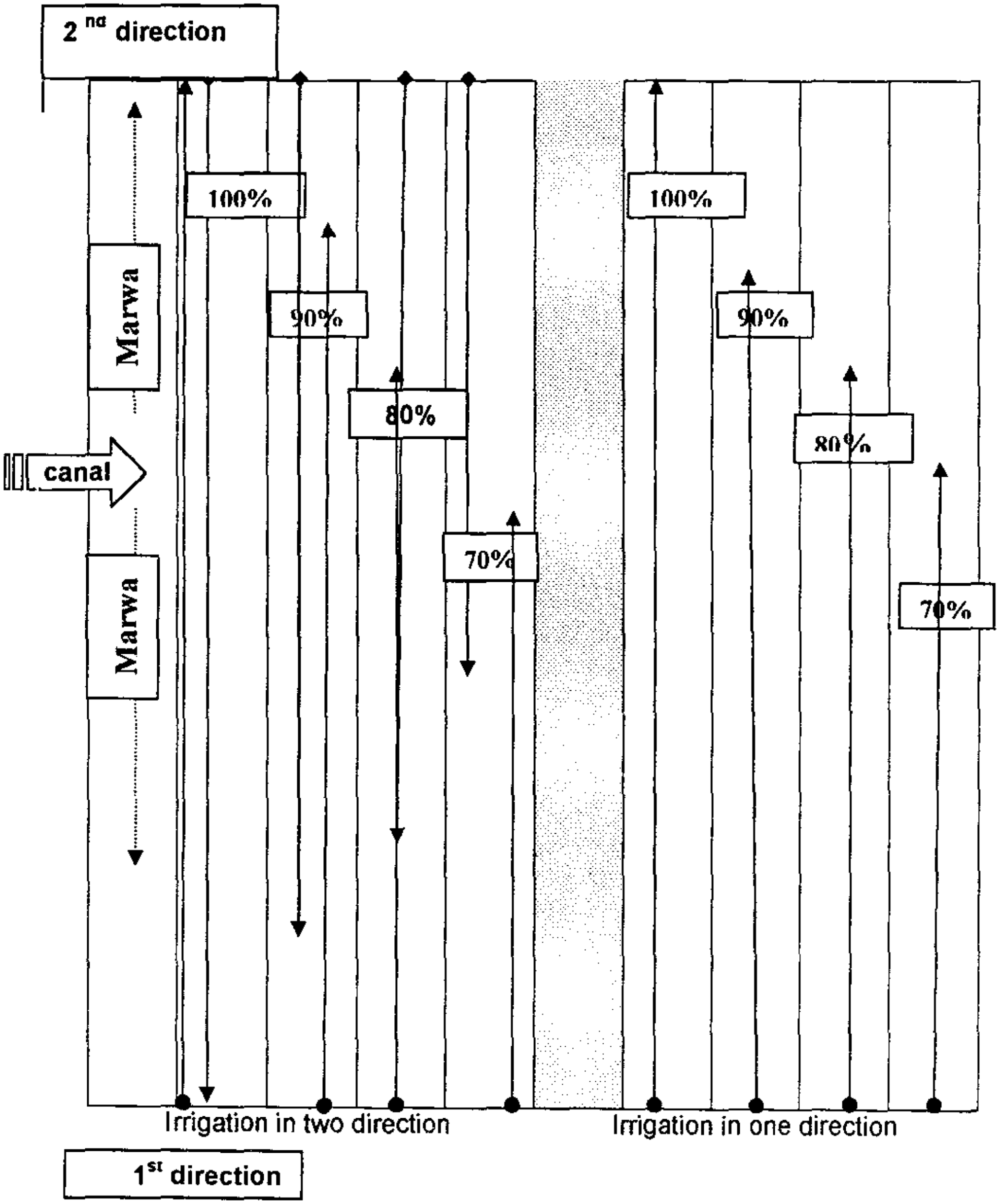


**Fig.(1): Schematic diagram for methods of irrigation**

Maize variety single hybrid 10 was planted in all treatments. on 20 and 25 of May and harvested on 11 and 8 September. of the growing successive seasons. All the agronomic practices except the irrigation treatments were carried out as commonly use in growing maize. The following characters were studied:

1- grain yield. (Ardab/fed and Kg/fed.)

2- Amount of irrigation water applied was measured by using a rectangular sharp crested weir. The discharge was calculated using the following formula:

$$Q = CLH^{3/2} \qquad \text{(Masoud, 1967)}$$

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.

3- **Water consumptive use** was calculated according to the following equation:

$$Cu = \sum_{i=i}^{n=1} \frac{\Theta 2 - \Theta 1}{100} \times B.d \times D \times 4200\ m2 \qquad \text{(Israelsen and Hansen, 1962):}$$

Where:

Cu = Amount of water consumptive use, ($m^3$/fed).
Θ2 = Soil moisture content in percent after irrigation.
Θ1 = Soil moisture content in percent before next irrigation.
B. d = Bulk density in g /$cm^3$.
n = number of irrigation.
I = number of soil layer.
D = Depth of the layer of the soil. (cm).
4200 = Area of feddan ($m^2$).

4- **Water application efficiency:** was computed by dividing water stored in the root zone on the applied irrigation water (Downy, 1970).

5- **Field water use efficiency:** is the weight of marketable crops produced per volume unit of applied water expressed as cubic meters of water (Michael, (1978) .

6- **Crop water use efficiency:** was computed by dividing the yield (Kg of grain) on water consumptive use expressed as cubic meters of water (Abd El-Rasool et al, 1971).

7- **Potential Evapotranspiration (ETp):**

Some meteorological data during the two growing seasons are presented in Table (3). Metrological data obtained from El Karada metrological station located at 31˚32 longitude.

**Table (3): Average temperature c°, relative humidity %, wind speed km/day during 2002 and 2003 seasons.**

| Months | 2002 | | | 2003 | | |
|---|---|---|---|---|---|---|
| | Average temperature c° | Relative humidity % | Wind speed kg/day | Average temperature c° | Relative humidity % | Wind speed km/day |
| May | 21.9 | 55.25 | 79.5 | 23.6 | 69.45 | 148 |
| June | 25.35 | 63.3 | 68 | 26.1 | 64.95 | 157 |
| July | 27.70 | 67.65 | 51.2 | 26.15 | 68.5 | 135 |
| Aug. | 26.95 | 65.3 | 52.1 | 26.8 | 73.15 | 94.94 |
| Sep. | 26.9 | 61.40 | 77 | 25.5 | 68.60 | 87.76 |

It has elevation of about 6 meter above the sea level. It represents conditions and circumstance of middle northern part of the Nile Delta. These data are used to get potential evapotranspiration mm/day by many empirical formulas.

**1-Modified penman equation:**

$$ETp = c\{(W.\ R_n + (1\text{-}w).\ f(u).\ (ea - ed)\}\ \text{mm/day.}$$

Where:

ETp = Reference crop Evapotranspiration mm/day.
W = Temperature – related weighting factor.
$R_n$ = Net radiation in equivalent evaporation in mm/day.
f (u) = Wind – related function
ea = Saturation vapor pressure of the air in (mm bar)
ed = Mean actual vapor pressure of the air in (mm bar)
= ea ×RH mean / 100, in which, RH= relative humidity.
(ea – ed) = Difference between the saturation vapor pressure at mean air temperature and the mean actual vapor pressure of the air, both in mbar.
C = Adjustment factor to compensate the effect of day and night weather conditions.

**2-Penman – Montieth Method**

The form of the penman –Montieth equation for estimating $ET_p$ recommended by the FAO expert consultation held in May 1990 in Rome is as follows:

$$ET_p = \frac{0.408\Delta(Rn - G) + yu2(ea - ed)\dfrac{900}{Tc + 273.15}}{\Delta + y(1 + 0.34u2)} \qquad \text{(FAO, 2000)}$$

Where:

$ET_p$ = reference Evapotranspiration (grass) (mm/d)
$R_n$ = net radiation at crop surface ($mj/m^2/d$)
G = Soil heat flux ($MJ/m^2/d$)
$T_c$ = average temperature (C°)
$U_2$ = wind speed at 2m height (m/s)
$e_a$ = saturation vapor pressure (kpa)
$e_d$ = (actual vapor pressure (kpa)
$\Delta$ = slope of the saturation vapor pressure curve at mean air
y = psychometrics constant (KPA/C°).

**3- Modified Blaney & Criddle equation:**

Blaney and Criddle (1950) observed that the amount of water consumptive used by crop during the growing seasons was closely correlated with means monthly temperature and day light hours.

$$ET_p = C\{p\ (0.64T + 8)\}\ \text{mm/day}$$

Where:

$ET_p$ = Potential evapotranspiration in mm/day.
T = Mean daily temperature in C.
P = Mean daily percentage of total annual day time hours for given month and Latitude.

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

**4- Radiation method**

$$ET_p = C \times W.Rs.$$

Where:

$ET_p$ = Reference crop Evapotranspiration in mm/day.

Rs = The solar radiation expressed in equivalent evaporation in m/day.

W = Weighting factor which depends on temperature and altitude.

C = Adjustment factor which depends on mean humidity and day time wind conditions.

**5- Pan evaporation method**

Reference Evapotranspiration ($ET_p$) can be obtained from the following Equation:

$$ET_p = Kp.\ E_{pan}\ \text{(mm/day)}$$

Where:

$K_p$ = Pan Coefficient, depends on type of pan condition of humidity, wind air speed and pan environmental conditions (=0.75).

$E_{pan}$ = Pan evaporation in mm/day and represents the mean daily value of the period considered.

**6- Crop Coefficient (Kc)**

Crop Coefficient defined as the ratio between actual crop evapotranspiration ($ET_a$) and potential evapotranspiration ($ET_p$) 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 evapotranspiration.

$ET_p$ = Potential evapotranspiration calculated by the five equations Penman Monteith, Modified Penman, Modified Blaney & Criddle, Radiation method, and Pan class A method).

**7- Return per unit of water:-**

In Egypt, water is provided without charge to the farmer but estimation of return per unit of water can be taken as index to the relation ship between water applied and the value of crop production (Division of Agricultural sciences Irrigation costs (1978).

**8- Economic efficiency:**

Refers to the combinations of inputs that maximize individual or social objectives. Economic efficiency is defined in terms of two conditions necessary and sufficient. Necessary condition is met in production process when there is producing the same amount of product with fewer inputs or producing more products with the same amount of inputs. But the sufficient condition for efficiency encompasses individual or social goals and values (John and Frank,1987).

## RESULTS AND DISCUSSION

### 1- Effect of irrigation in two directions and cut back stream treatments on grain production:

Values of grain maize yield as affected by the different treatments are presented in Table. (4) The statistical analysis of data indicated that the irrigation in two directions treatments had significant effect on the productivity of maize yield treatment $A_2$ (irrigation in two directions) and achieved the highest value. On the other hand the cut back stream treatments had highly significant effect. The highest values of grain yield were recorded from treatments $B_1$ and $B_2$ respectively. The interaction between the different treatments had no significant effect on the productivity of grain maize yield.

**Table (4): Yield of maize as affected by irrigation in two directions and cut back stream treatments in 2002 and 2003 seasons.**

| Treatments | 2002 | 2003 |
|---|---|---|
| | Ardab/Fed. | Ardab/Fed |
| Irrigation in two direction | | |
| One directions($A_1$) | 19.01 | 19.35 |
| Two directions($A_2$) | 20.25 | 20.59 |
| Mean | 19.63 | 19.97 |
| F . test | * | * |
| L.S.D $_1$% | - | |
| L.S.D $_5$% | 0.79 | 1.13 |
| Cut back stream. | | |
| Irrigation all the furrow ($B_1$) | 21.83 | 22.17 |
| Irrigation 90% of the Furrow length ($B_2$) | 21.50 | 21.83 |
| Irrigation 80% of the Furrow length ($B_3$) | 18.67 | 19.00 |
| Irrigation 70% of the Furrow length ( $B_4$) | 16.52 | 16.86 |
| Mean | 19.63 | 19.97 |
| F Test | ** | ** |
| L.S.D $_1$% | 2.59 | 2.6 |
| L.S.D $_5$% | 1.39 | 1.4 |
| Interaction A. x B | N.S. | N.S |

### 2- Effect of irrigation in two directions and cut back stream treatments on seasonal irrigation water applied and water saving:-

The amount of applied irrigation water $m^3$/Fed. and water saving to different irrigation treatments are shown in Table. (5) and Fig. (2). The average amounts of water were 2364.4 and 2354.77 $m^3$/Fed under $A_1$ and $A_2$ treatments, respectively, while they were 2763.36 . 2496.47, 2195.91 and 1984.63 $m^3$/fed. under $B_1$, $B_2$, $B_3$ and $B_4$ treatments, respectively. Concerning the water saving the data showed that water saving was increased by increasing cut back streams. The average water saving were 266.89, 567.45 and 778.74 $m^3$/Fed. under $B_2$, $B_3$ and $B_4$ treatments respectively comparing with treatment $B_1$. It could be concluded that average saved water percentage were 9.66, 20.54 and 28.18 % under cut back stream when water reached 90, 80 and 70 % of the furrow length, respectively.

**Table (5): Total water applied (m$^3$/fed.), saved water (m$^3$/fed.) and saved water percentage of maize crop as affected by irrigation in two direction and cut back stream treatments in 2002 and 2003 seasons**

| Treats. | | 2002 | | | 2003 | | | average | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Water applied, m$^3$/fed | Saved water, m$^3$/fed | Saved water, % | Water applied, m$^3$/fed | Saved water, m$^3$/fed | Saved water, % | Water applied, m$^3$/fed | Saved water, m$^3$/fed | Saved water, % |
| $A_1$ | $B_1$ | 2764.59 | - | | 2784.4 | - | - | 2774.5 | | |
| | $B_2$ | 2486.42 | 278.17 | 10.06 | 2504.42 | 279.98 | 10.06 | 2495.42 | 279.08 | 10.06 |
| | $B_3$ | 2191.29 | 573.3 | 20.74 | 2208.3 | 576.1 | 20.69 | 2199.8 | 574.7 | 20.72 |
| | $B_4$ | 1984.30 | 780.29 | 28.22 | 1999.5 | 784.9 | 28.19 | 1991.9 | 782.6 | 28.21 |
| $A_2$ | $B_1$ | 2742.21 | - | | 2762.21 | - | | 2752.21 | 0 | 0 |
| | $B_2$ | 2479.60 | 262.61 | 9.58 | 2515.42 | 246.79 | 8.93 | 2497.51 | 254.7 | 9.26 |
| | $B_3$ | 2185.54 | 556.67 | 20.3 | 2198.5 | 563.71 | 20.41 | 2192.02 | 560.19 | 20.36 |
| | $B_4$ | 1971.19 | 771.02 | 28.12 | 1983.5 | 778.71 | 28.19 | 1977.35 | 774.87 | 28.16 |

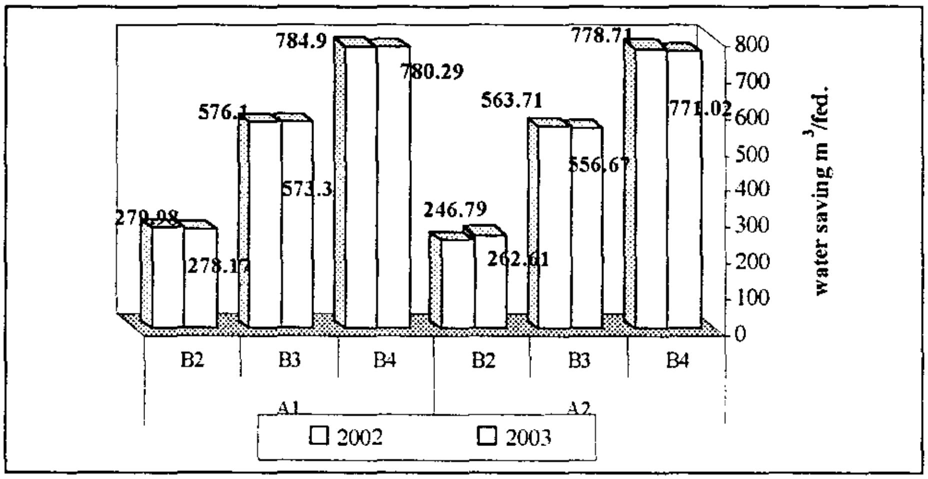


Fig.(2) water saving m$^3$/fed. On seasons 2002 and 2003

**3- Daily, monthly and seasonal actual water consumptive use:**

Daily, monthly and seasonal actual water consumptive use values are presented in Tables (6) and (7) and figures (3) and (4). Obtained data indicated that daily and monthly water consumptive use gradually increased until reached its maximum values within July during the two growing seasons. This means that its peak value in the middle of the growing season which is considered the critical period in water demands of maize crop. The mean values of seasonal water consumptive use were 512.7, 461.7, 423.7 and 396.2 cm with $A_1$ under $B_1$, $B_2$, $B_3$ and $B_4$ treatments respectively and 505.5, 456.4, 424.3 and 392 cm with $A_2$ under the previous treatments respectively in the first season while average of seasonal water consumptive use for the same treatments were 519.7, 470.7, 430.7 and 398.7 and 493.9, 457.2, 429.5 and 391.2 cm in the second season respectively. These results revealed that water consumptive use increased due to increasing amount of water applied.

Table (6): Daily, Monthly and Seasonal actual water consumptive use during 2002 season

| Months | May | | June | | July | | august | | September | | Total seas. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Treat | D mm | M. mm | D mm | M. mm | D mm | M. mm | D mm | M. mm | D mm | M. mm | |
| $A_1B_1$ | 2 | 22 | 4 | 120 | 6 | 186 | 5 | 155 | 2.7 | 29.7 | 512.7 |
| $A_1B_2$ | 2 | 22 | 3.5 | 105 | 5.5 | 170.5 | 4.5 | 139.5 | 2.7 | 29.7 | 461.7 |
| $A_1B_3$ | 2 | 22 | 3 | 90 | 5 | 155 | 4.1 | 127. | 2.7 | 29.7 | 423.7 |
| $A_1B_4$ | 2 | 22 | 2.7 | 81 | 4.7 | 145.7 | 3.8 | 117.8 | 2.7 | 29.7 | 396.2 |
| Aver | 2 | 22 | 3.3 | 99 | 5.3 | 164.3 | 4.4 | 134.8 | 2.7 | 29.7 | |
| $A_2B_1$ | 1.9 | 20.9 | 3.9 | 117 | 5.9 | 182.9 | 5 | 155 | 2.7 | 29.7 | 505.5 |
| $A_2B_2$ | 1.9 | 20.9 | 3.4 | 102 | 5.3 | 164.3 | 4.5 | 139.5 | 2.7 | 29.7 | 456.4 |
| $A_2B_3$ | 1.9 | 20.9 | 3 | 90 | 4.9 | 151.9 | 4.2 | 131.4 | 2.7 | 29.7 | 424.3 |
| $A_2B_4$ | 1.9 | 20.9 | 2.7 | 81 | 4.7 | 144.2 | 3.7 | 116.3 | 2.7 | 29.7 | 392 |
| Aver. | 1.9 | 20.9 | 3.3 | 97.5 | 5.2 | 160.8 | 4.4 | 135.6 | 2.7 | 29.7 | |

Table (7): Daily, Monthly and Seasonal actual water consumptive use during 2003 season

| Mont | May | | June | | July | | august | | September | | Total. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| treat | D mm | M. mm | D mm | M. mm | D mm | M. mm | D mm | M. mm | D mm | M. mm | |
| $A_1B_1$ | 2.1 | 27.3 | 4.1 | 123 | 6.1 | 189.1 | 5.1 | 158.1 | 2.4 | 19.2 | 519.7 |
| $A_1B_2$ | 2.1 | 27.3 | 3.6 | 108 | 5.6 | 173.6 | 4.6 | 142.6 | 2.4 | 19.2 | 470.7 |
| $A_1B_3$ | 2.1 | 27.3 | 3.1 | 93 | 5.2 | 161.2 | 4.2 | 130 | 2.4 | 19.2 | 430.7 |
| $A_1B_4$ | 2.1 | 27.3 | 2.7 | 82.5 | 4.85 | 150.4 | 3.85 | 119.4 | 2.4 | 19.2 | 398.7 |
| Aver | 2.1 | 27.3 | 3.4 | 1016 | 5.44 | 168.6 | 4.44 | 137.5 | 2.4 | 19.2 | |
| $A_2B_1$ | 2 | 26 | 3.9 | 117 | 5.8 | 179.8 | 4.40 | 151.9 | 2.4 | 19.2 | 493.9 |
| $A_2B_2$ | 2 | 26 | 3.4 | 102 | 5.3 | 164.3 | 4.70 | 145.7 | 2.4 | 19.2 | 457.2 |
| $A_2B_3$ | 2 | 26 | 3.2 | 96 | 4.95 | 153.5 | 4.35 | 134.8 | 2.4 | 19.2 | 429.5 |
| $A_2B_4$ | 2 | 26 | 2.7 | 82.5 | 4.75 | 147.3 | 3.75 | 116.3 | 2.4 | 19.2 | 391.2 |
| aver | 2 | 26 | 3.3 | 99.4 | 5.20 | 161.2 | 4.43 | 137.2 | 2.4 | 19.2 | |

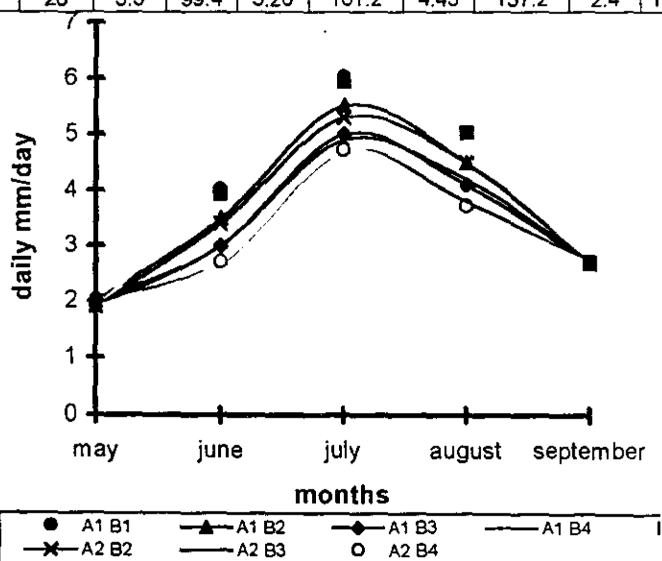


Figure (3): Daily actual water consumptive use during 2002 season

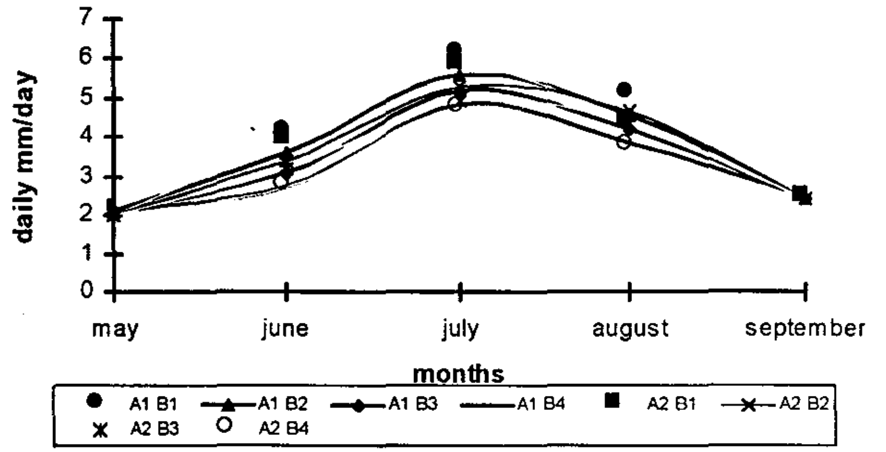


**Figure (4): Daily actual water consumptive use during 2003 season**

**4- Water application efficiency, Water use efficiency and utilization efficiency.**

Values of water application efficiency, water use efficiency and utilization efficiency as influenced by the different treatments are shown in Tables (8)&(9). Data indicated that water application efficiency increased with decreasing applied irrigation water. The highest value was recorded with $B_4$ treatment. Also, it is noticed that the highest values of water use and utilization efficiency were achieved with treatment $B_2$ in the two seasons.

**Table (8): Maize grain yield, amount of irrigation water, water consumptive use, water application efficiency, crop water use efficiency and field water use efficiency as affected by irrigation in two directions and cut back stream treatments during 2002 season**

| Treatments | | Maize grain yield, Kg/fed | Water require., m³/fed | Water consumpt., use m³/fed | Water Applic., efficiency % | crop water use efficiency, Kg/ m³ | field water use efficiency, Kg/ m³ |
|---|---|---|---|---|---|---|---|
| $A_1$ | $B_1$ | 2986.2 | 2764.59- | 2182.74 | 78.39 | 1.39 | 1.09 |
| | $B_2$ | 2940 | 2504.42 | 1976.94 | 78.94 | 1.51 | 1.19 |
| | $B_3$ | 2520 | 2208.30 | 1808.94 | 81.92 | 1.42 | 1.16 |
| | $B_4$ | 2199.4 | 1983.50 | 1674.54 | 84.420 | 1.34 | 1.13 |
| $A_2$ | $B_1$ | 3126.2 | 2762.21 | 2074.38 | 75.10 | 1.53 | 1.15 |
| | $B_2$ | 3080 | 2501 | 1420.24 | 76.78 | 1.63 | 1.25 |
| | $B_3$ | 2706.2 | 2198.50 | 1803.90 | 82.05 | 1.53 | 1.25 |
| | $B_4$ | 2426.2 | 1963.50 | 1643.04 | 83.68 | 1.51 | 1.26 |

**Table (9): Maize grain yield, amount of irrigation water, water consumptive use, water application efficiency, crop water use efficiency and field water use efficiency as affected by irrigation in two directions and cut back stream treatments during 2003 season**

| Treatments | | Maize grain yield, Kg/fed | Water requirements, $m^3$/fed | Water consumpt. use, $m^3$/fed | Water application efficiency, % | crop water use efficiency, Kg/ $m^3$ | field water use efficiency, Kg/ $m^3$ |
|---|---|---|---|---|---|---|---|
| $A_1$ | $B_1$ | 3033.8 | 2784.40 | 2182.74 | 78.39 | 1.39 | 1.09 |
| | $B_2$ | 2986.2 | 2504.42 | 1976.94 | 78.94 | 1.51 | 1.19 |
| | $B_3$ | 2566.2 | 2208.30 | 1808.94 | 81.92 | 1.42 | 1.16 |
| | $B_4$ | 2247 | 1983.50 | 1674.54 | 84.42 | 1.34 | 1.13 |
| $A_2$ | $B_1$ | 3173.8 | 2762.21 | 2074.38 | 75.10 | 1.53 | 1.15 |
| | $B_2$ | 3126.2 | 2501 | 1920.24 | 76.78 | 1.63 | 1.25 |
| | $B_3$ | 2753.8 | 2198.50 | 1803.90 | 82.05 | 1.53 | 1.25 |
| | $B_4$ | 2473.8 | 1963.50 | 1643.04 | 83.68 | 1.51 | 1.26 |

## 4.2 Potential Evapotranspiration:-

Data in Tables (10) and (11) showed the computed values of daily, Monthly and seasonal evapotranspiration (mm/day, mm/month and mm/season) according to Penman Montieth, Modified Penman, Modified Blaney & Criddle, Radiation and Pan class A equations for two studied seasons. It can be noticed that the highest potential Evapotranspiration (ETp) was obtained from radiation and Modified penman, while the lowest was obtained from Pan class A. It could be concluded that the nearest $ET_P$ to the average were obtained from Modified penman and pan class A in the first and second seasons respectively.

**Table (10): Computed daily, monthly and seasonal evapotranspiration (mm/day) according to Penman Montieth, Modified Penman, Modified Blaney & Criddle, Radiation and Pan class A equations during 2002**

| Empirical | May | | June | | July | | August | | September | | S.Etp, mm/ seas. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | D. | M | D. | M | D. | M | D. | M | D. | M | |
| Penman Montieth | 5.1 | 66.3 | 6 | 180 | 5.8 | 179.8 | 5.2 | 161.2 | 4.3 | 34.4 | 621.7 |
| Modified Penman | 6.2 | 79.9 | 7.36 | 220.8 | 6.89 | 213.4 | 6.04 | 187.24 | 5.2 | 41.36 | 742.94 |
| Modified Blaney & Criddle | 4.4 | 57.3 | 5.97 | 179.1 | 5.75 | 178.3 | 5.44 | 168.64 | 4.8 | 38.48 | 621.80 |
| Radiation | 6.04 | 78.5 | 7.08 | 212.4 | 6.88 | 213.3 | 5.8 | 180.11 | 5.4 | 43.2 | 727.51 |
| Pan class A | 5.5 | | 5.09 | | 4.98 | | 5.1 | | 3.97 | | 671.48 |
| Average | | | | | | | | | | | 677.09 |

**Table (11): Computed daily, monthly and seasonal evapotranspiration (mm/day) according to Penman Montieth, Modified Penman, Modified Blaney & Criddle, Radiation and Pan class A equations during 2002**

| Empirical | May | | June | | July | | August | | September | | S. Etp,mm/ seas. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | D. | M | D. | M | D. | M | D. | M | D. | M | |
| Penman Monteith | 5.8 | 63.6 | 6.6 | 197.4 | 6.51 | 201.81 | 6.18 | 191.6 | 5.5 | 60.3 | 714.65 |
| Modified Penman | 5.3 | 58.3 | 6 | 180 | 5.8 | 179.8 | 5.6 | 173.6 | 4.9 | 53.2 | 644.90 |
| Modified Blaney & Criddle | 4.1 | 45.1 | 5.8 | 174 | 6 | 186 | 5.3 | 164.3 | 5 | 55 | 624.40 |
| Radiation | 6.1 | 67.1 | 7 | 210 | 7 | 217 | 6.6 | 204.6 | 5.5 | 60.5 | 759.20 |
| Pan class A | 4.65 | 51.12 | 5.6 | 168 | 5.04 | 156.24 | 4.69 | 145.4 | 4.2 | 45.9 | 566.62 |
| Average | | | | | | | | | | | 661.95 |

## 4 Crop Coefficient (Kc)

Effect of crop characteristics on crop water requirements is indicated by the crop coefficient (Kc), which represents the relationship between potential (ETp) and actual Evapotranspiration (ETa).

Data of crop coefficient of maize crop for different irrigation treatments are shown in Tables (12) and (13) and figures (5) and (6). It is cleared that the average value of crop coefficient Kc by many empirical formulas were 0.39, 0.54, 0.88, 0.78, and 0.54 and 0.38, 0.54, 0.89, 0.80 and 0.52 in May, June, July, Aug. and Sep. in the first and second seasons, respectively. It could be noticed that the nearest value to average (Kc), those of Modified Penman and Penman Montieth in the first and second seasons respectively. So, it can be concluded that the value of 0.63 for crop coefficient can be used to calculate evapotranspiration of maize plant grown in North Delta by using Penman Montieth equation.

**Table (12): Crop Coefficient for maize crop as affected by different treatments during season 2002**

| Months | Aver. A W.C.U mm/ day | Penman Montieth | | Modified Penman | | Modified Blaney &Criddle | | Radiation | | Pan class A | | Aver. Kc |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | D. | Kc | D. | Kc | D. | Kc | D. | Kc | D. | Kc | |
| May | 1.95 | 5.78 | 0.34 | 5.3 | 0.37 | 4.1 | 0.48 | 6.1 | 0.32 | 4.65 | 0.42 | 0.39 |
| Jun. | 3.28 | 6.58 | 0.5 | 6 | 0.55 | 5.8 | 0.57 | 7 | 0.47 | 5.6 | 0.59 | 0.54 |
| Jul. | 5.25 | 6.51 | 0.81 | 5.8 | 0.9 | 6 | 0.88 | 7 | 0.75 | 5.04 | 1.04 | 0.88 |
| Aug. | 4.36 | 6.18 | 0.71 | 5.6 | 0.78 | 5.3 | 0.82 | 6.6 | 0.66 | 4.69 | 0.93 | 0.78 |
| Sept. | 2.7 | 5.48 | 0.49 | 4.9 | 0.55 | 5 | 0.54 | 5.5 | 0.49 | 4.17 | 0.65 | 0.54 |
| | | | 0.57 | | 0.63 | | 0.66 | | 0.54 | | 0.73 | 0.63 |

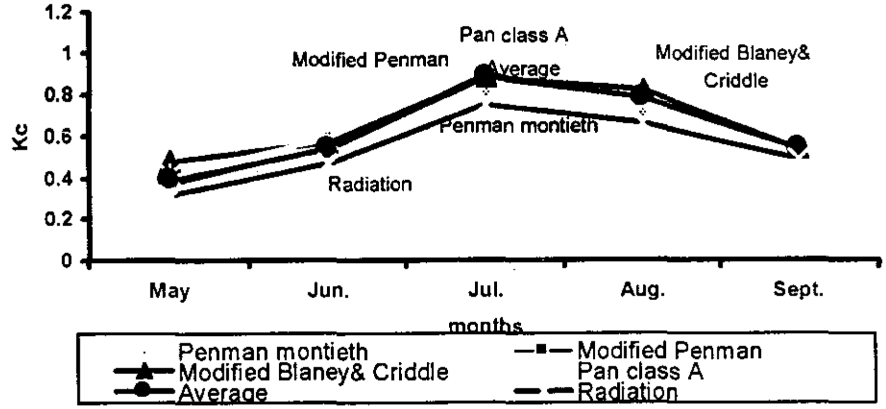


Figure (5): Crop Coefficient for maize crop as affected by different treatment during season 2002

Table (13): Crop Coefficient for maize crop as affected by different treatment during season 2003

| Months | Aver. A W.C.U mm/ day | Penman Montieth | | Modified Penman | | Modified Blaney & Criddle | | Radiation | | Pan class A | | Aver. Kc |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | D. | Kc | D. | Kc | D. | Kc | D. | Kc | D. | Kc | |
| May | 2.05 | 5.1 | 0.4 | 6.15 | 0.33 | 4.41 | 0.46 | 6.04 | 0.34 | 5.47 | 0.37 | 0.38 |
| Jun. | 3.35 | 6 | 0.56 | 7.36 | 0.46 | 5.97 | 0.56 | 7.08 | 0.47 | 5.09 | 0.66 | 0.54 |
| Jul. | 5.32 | 5.8 | 0.92 | 6.89 | 0.77 | 5.75 | 0.93 | 6.88 | 0.77 | 4.98 | 1.07 | 0.89 |
| Aug. | 4.43 | 5.2 | 0.85 | 6.04 | 0.73 | 5.44 | 0.81 | 5.81 | 0.76 | 5.1 | 0.87 | 0.8 |
| Sept. | 2.4 | 4.3 | 0.56 | 5.17 | 0.46 | 4.81 | 0.5 | 5.4 | 0.44 | 3.97 | 0.6 | 0.52 |
| | | | 0.66 | | 0.55 | | 0.65 | | 0.56 | | 0.71 | 0.63 |

A.W. C. U. =actual water consumptive use. D. = daily actual water consumptive use.
Kc.=Crop Coefficient. M. =monthly actual water consumptive use.

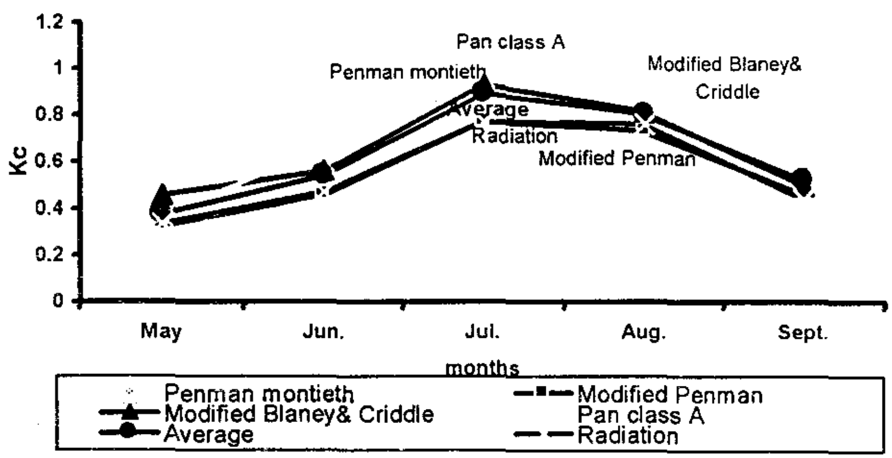


Figure (6): Crop Coefficient for maize crop as affected by different treatments during season 2003

## 6- The economic evaluation

Data in Tables (13) and (14) illustrated the values of production, total income, total costs, total return, water applied, water productivity and economic efficiency as influenced by different treatments for maize crop in the first and second seasons. Data obtained indicated that the maximum values of total income, total return, water productivity and economic efficiency were achieved with $A_2$ (irrigation in two direction treatment). In the first and second seasons. Concerning the effect of cut back stream treatments, the maximum values were obtained with $B_1$ and $B_2$ treatments respectively in the first and second seasons .

**Table (13): Values of productivity, total income, total costs, total return, water applied and water productivity for maize crop under**

| Treatments | Produ., ardab/ fed | Total Income, LE/ fed | Costs | | | Total Return, LE/ fed | Water Applied, $m^3$/fed | Water Produ., LE/ $m^3$ | Economic efficiency |
|---|---|---|---|---|---|---|---|---|---|
| | | | Variable, LE/ fed | Fixed, LE/ fed | Total, LE/ fed | | | | |
| $A_1B_1$ | 21.33 | 3199.5 | 1206 | 560 | 1766 | 1433.5 | 2764.59 | 0.52 | 0.81 |
| $A_1B_2$ | 21 | 3150 | 1196 | 560 | 1756 | 1394 | 2486.42 | 0.56 | 0.79 |
| $A_1B_3$ | 18 | 2700 | 1186 | 560 | 1746 | 954 | 2191.29 | 0.44 | 0.55 |
| $A_1B_4$ | 15.71 | 2356.5 | 1176 | 560 | 1736 | 620.5 | 1984.30 | 0.31 | 0.36 |
| mean | | 2851.5 | | | | 1100.5 | | 0.46 | 0.63 |
| $A_2B_1$ | 22.3 | 3349.5 | 1206 | 560 | 1766 | 1583.5 | 2742.21 | 0.58 | 0.90 |
| $A_2B_2$ | 22.00 | 3300 | 1196 | 560 | 1756 | 1544 | 2479.60 | 0.62 | 0.88 |
| $A_2B_3$ | 19.33 | 2899.5 | 1186 | 560 | 1746 | 1153.5 | 2185.54 | 0.53 | 0.66 |
| $A_2B_4$ | 17.33 | 2599.5 | 1176 | 560 | 1736 | 863.5 | 1971.19 | 0.44 | 0.50 |
| mean | | 3037.1 | | | | 1286.1 | | 0.54 | 0.74 |

**Table (14): Values of productivity, total income, total costs, total return, water applied and water productivity for maize crop under different treatments during season 2003different treatments during season 2002**

| Treatments | Produ., ardab/ fed | Total Income, LE/ fed | costs | | | Total Return, LE/ fed | Water Applied, $m^3$/fed | Water Produ, LE/ $m^3$ | Economic efficiency |
|---|---|---|---|---|---|---|---|---|---|
| | | | Variable, LE/ fed | Fixed, LE/ fed | Total, LE/ fed | | | | |
| $A_1B_1$ | 21.67 | 3250.50 | 1206 | 560 | 1766 | 1484.5 | 2784.40 | 0.53 | 0.84 |
| $A_1B_2$ | 21.33 | 3199.5 | 1196 | 560 | 1756 | 1443.5 | 2504.42 | 0.58 | 0.82 |
| $A_1B_3$ | 18.33 | 2749.5 | 1186 | 560 | 1746 | 1003.5 | 22.83.30 | 0.45 | 0.58 |
| $A_1B_4$ | 16.05 | 2407.50 | 1176 | 560 | 1736 | 671.5 | 1983.5 | 0.34 | 0.39 |
| mean | | 2901.75 | | | | 1150.7 | | 0.48 | 0.66 |
| $A_2B_1$ | 22.67 | 3400.50 | 1206 | 560 | 1766 | 1634.5 | 2762.21 | 0.59 | 0.93 |
| $A_2B_2$ | 22.33 | 3344.50 | 1196 | 560 | 1756 | 1593.5 | 2515.42 | 0.63 | 0.91 |
| $A_2B_3$ | 19.67 | 2950.5 | 1186 | 560 | 1746 | 1204.5 | 2198.5 | 0.55 | 0.69 |
| $A_2B_4$ | 17.67 | 2650.5 | 1176 | 560 | 1736 | 914.50 | 1963.5 | 0.47 | 0.53 |
| mean | | 3087.75 | | | | 1336.7 | | 0.56 | 0.77 |

## REFERENCES

Abd El-Rasool, S. F. ; H. W. Tawadros; W. I. Miseha and F. N. Mahrous (1971). Effect of irrigation and ferilization on water use efficiency by wheat ferilizer. Conf. Ein Shams Univ., Cairo, Egypt. Pp: 76-88.

Abdel-Maksoud, H. H. and A. N., Khater (1997). Improving surface irrigation performance through the other-row and surge irrigation technique. Misr J. Ag.Eng., 14 (2): 170-180.

Bassett, D. L. and R. G. Evans (1983). Surge irrigation research at Washington State University. Western Regional project W-163 Work shop. Salt Lake City, UT. 2pp.

Black, C. A. (1965). Methods of Soil Analysis. Amer Soc. Agron. Inc, Madison, Wisconsin U. S. A.

Blaney, H. F. and Criddle, W. D. (1955). Determining water Requirements in irrigated area from Climatologically and Irrigation data. USDA soil Conserve. Serve. SCS-T p 96-44pp. Division of Agricultural sciences Irrigation costs – University of California – August 1978.

Downy, L. A. (1970). Water use by maize at three plant densities. Exper. Agr. 7 : 161 – 169.

El-Sherbeny, A. M. ; M. I. Ward and A. A. El –Behery. (1997). Evaluation of alternate irrigation technique under furrow irrigation system. 5th conference of Misr Society of Ag. Eng: 9th September.

FAO. (1977) " Crop water requirement" FAO Irrigation and drainage paper No. 24. Rome 1977.

FAO. (2000). Crops and drops: making the best use of water for agriculture. FAO Advance Edition. Rome.

Israelsen, O. W., and V. E. Hansen (1962). Irrigation principles and practices. 3rd Edit. John Willey & Sons. Inc., New York.

John P. Doll, and O Frank (1987) Production economics-Theory with applications, Second edition-Library of congress cataloging in publication data. M. S A-New York.

Masoud, F. I. (1967). Water, soil and plant relationship. New publication house, Alexandria. (In Arabic)

Michael, A. M. (1978). Irrigation theory and practice. Vika Publishing house, New Delhi (1978).

Morsi, T. M. A. (2001). A study on irrigation systems developing of Furrow irrigation method for corn crop under local conditions. M. sc. Thesis Fac. Agr. Tanta univ. Egypt

## ادارة المياه لمحصول الذرة في شمال الدلتا

**محمد ابراهيم مليحه**
**معهد بحوث ادارة المياه وطرق الري – المركز القومي لبحوث المياة – القاهرة –مصر**

ادارة المياه اصبحت قضية هامة(اساسية) خاصة في المناطق الجافة وشبه الجافة التى تتميز بندرة او محدودية مصادر المياه. مصر غير مستثناة من الدول الأخرى التي تقع في تلك المناطق. اذا لم يتم اخذ قياسات لصيانة وحماية استدامة الري سوف نواجه مشكلة المياه في المستقبل القريب لذلك فانه من الضروري ان تكتشف مصر وسائل وتقنيات لتطوير وتوجيه وادارة واستخدام مصادرها المائية بكفاءة اكثرلمواجهة الطلب المتزايد على المياه

اقيمت تجربتين حقليتين خلال موسمين صيفيين متتاليين وهما ٢٠٠٢و ٢٠٠٣الدراسة تاثير الري في اتجاهين و ايقاف سريان الماء في الخطوط على محصول الذرة وتوفير المياه في محطة بحوث القرضا بمحافظة كفر الشيخ معهد بحوث إدارة المياه– المركز القومي لبحوث المياه اوضحت النتائج انه عندما تصل المياه نهاية لو ٩٠% من الخط كانت احسن المعاملات سواء الفردية او المشتركة للحصول على اقصى محصول حبوب كما اوضحت النتائج ان:–

–يمكن توفير المياة بمعدل ٢٦٨,٦٤ م٣/فدان (٩,٦٦%) و٥٦٧,٤٥م٣/فدان ((٢٠,٥٤%) و ٧٧٨ م٣/فدان (٢٨,١٨%) بالنسبة لمياه الري المضافة تحت ايقاف سريان الماء في الخطوط عندما تصل المياه الي ٩٠% و ٨٠% و ٧٠% من طول الخط على التوالي.

– زاد الاستهلاك المائي بزيادةمياه الري المضافة.

– كانت اعلى القيم لكفاءة تطبيق واستخدام المياه مع الري في اتجاهين و ايقاف سريان الماء في الخطوط عندما وصلت المياه ٧٠% من طول الخط بينما كانت أعلى القيم لكفاءة استخدام المحصول للمياه مع ايقاف سريان الماء في الخطوط عندما وصلت المياه ٨٠% من طول الخط.

– اقصى قيم للدخل الكلى والعائد الكلي ولنتاجية المياه والتقييم الاقتصادى تم الحصول عليه من النباتات النامية تحت الري في اتجاهين مع ايقاف سريان الماء في الخطوط عندما تصل المياه ٩٠% من طول الخط

يمكن ان نقترح من النتائج انه عندما نستخدم لايقاف سريان الماء في الخطوط عندما تصل المياه الي ٩٠% من طول الخط يمكن توفير مياه ري تقريبا ٢٦٨,٦٤ م٣/فدان. ١٥,٥١٣٩٦٠ مليون م٣/ مساحة٥٧٧٥٠) فدان(تحت ظروف كفر الشيخ هذه الكميات من المياه المتوفرة تكفي لزراعة مساحة ٥٦٠١,٩٧ فدان تحت ظروف كفر الشيخ.