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COTTON CROP PRODUCTION USING DIFFERENT IRRIGATION SYSTEMS

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ABESTRACT

The present field experiments were carried out in the Experimental Farm of the Faculty of Agriculture, Kafr El-Sheikh University, Kafr El-Sheikh during successive seasons 2003/2004 and 2004/2005. Cotton (Giza 89 variety, long-staple) was sown on April 24th and 22nd during 2003/2004 and 2004/2005 keeping spacing of 0.70 m between rows and 0.30 m between hills within the row. The present research included the following factors:

a) Irrigation system: Three irrigation systems were used (traditional furrow, alternate and drip).

b) Furrow and lateral line length: Four lengthen of furrow and lateral lines were used in the present study (20; 40; 60 and 80 m).

The results indicated that:-

- *The average values of the total irrigation water applied to cotton crop were 3090, 2608 and 2135 m^3/fed. for furrow, alternative and drip irrigation, respectively. The amount of saved water was 482 and 955 m^3/fed. for alternate and drip irrigations, respectively compared to furrow irrigation method.*
- *Increasing drip line length led to a decline in the water distribution along the line.*
- *Maximum value of LAI was 6.13 obtained with traditional furrow irrigation at 100 days from planting date (near peak bloom) and 80 m furrow length.*
- *Drip irrigation systems, in general, provide only marginal improvements to water use efficiency under cotton region climate and soil conditions.*
- *The average cotton yield values were 4.89, 5.69 and 4.93 Kentar[1]/fed. for traditional furrow, alternative furrow and drip irrigation methods, respectively.*

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[1] 1 Kentar = 157.5 kg

- *The maximum value of water use efficiency was 0.43 kg/m^3 using drip irrigation system and 20 m drip line length. The worst value was 0.21 kg/m^3 obtained with traditional furrow irrigation at 80 m furrow length.*

INTRODUCTION

Enhancing agricultural productivity has become essential to meet food demands for the ever growing population. Thus, available water for irrigation needs to be utilized judiciously. Viewed from the perspective of water stress, the purpose of irrigation is to keep water status at a level that maximizes yield within the constraints of irrigation supply and growing season weather. Cotton is the most important crop in Egypt. Irrigation method for cotton production in Egypt is the furrow method. The farmers use, generally, over irrigation water, which results in high losses and low irrigation efficiencies, thus in turn causes drainage and salinity problems.

Mahrous (1977) found that water through drip was reduced to 75%, the increase in seed cotton yield was 12%; however, when water was reduced to 50%, it resulted in 2% lower yield than check basin. ***Doorenbos and Kassam (1979)*** indicated that the maximum corn and cotton yields were usually obtained when the corn and cotton plants were irrigated at 50–60% of available water capacity, respectively. The measured soil moisture level at 100 % of available water for corn and cotton was used to initiate irrigation of cotton and corn during the growing season. ***Grims and El-Zik (1982)*** concluded that the irrigation management has controlling effect of growth and earliness of cotton. Techniques such as trickle irrigation might be useful in growing short season cotton, controlled plant water, since stress is desirable for earliness and maximum yield. Cotton yield is dependent upon the production and the retention of bolls, and both can be decreased by water stress (***Guinn and Mauney, 1984***). ***Wilson et al. (1984)*** found that converting from furrow to drip irrigation for cotton resulted in reduced water use, and increased yields. ***Bucks et al. (1988)*** reported that wider spacing of drip laterals than in-row placement was adequate for cotton production in Arizona. Burying of the drip systems, so they can be reused for several years, reduces labor and materials cost by eliminating annual removal and installation of the systems. ***Ali (1990)*** used three irrigation intervals i.e. 10, 15, 20 days to irrigate Giza 81 cotton variety. He found that elongation of irrigation intervals increased boll weight, seed index, fiber length (2.5 % span length), fiber fineness and fiber strength. Lint percentage was increased as irrigation intervals decreased. The irrigation every 15 days recorded the highest seed cotton yield and number of open bolls per plant. ***Camp et al. (1993)*** demonstrated cotton with alternate-furrow (2-m spacing) placement for laterals placed on the soil surface in the southeastern Coastal plain. On a coarse-textured soil in Arizona, cotton yields were comparable for laterals placed either every row (1-m spacing) or every other row (2-m spacing), but were 39% lower for laterals placed every third row (3-m spacing). Highest row cotton yield was obtained from the drip irrigated plots with 4650 kg per hectare followed by sprinkler with 3710 kg/ha and Low energy precision application (LEPA) with 3210 kg/ha, and furrow method resulted in a yield level of 3120 kg/ha. The amount of irrigation water applied varied from 726 mm for sprinkler, 1059 mm for mobile drip, 1076 mm for LEPA, 1003 mm for furrow and to 987 mm for drip method (***Cetln et al., 1994***). Drip-irrigated cotton was first used commercially in Texas in 1984. The economic benefit derived from drip-cotton come from labor savings, reduced cultivations, increased yield on the drip-irrigated plots and a corresponding increase in yields on the conventionally irrigated fields (***Henggeler, 1995***). A similar research was carried out to determine the effects of different irrigation methods namely LEPA, drip, sprinkler, mobile drip, and furrow irrigation methods on the yield, fiber quality and water use efficiency of cotton in the Menemen Plain in the Aegean Region of Turkey. In the experiment, various pan coefficients varying from 0.25 to 1.5 increasing at 0.25 increments were used. According to research results, the amount of pan coefficient of 0.75 resulted in the highest yield. Higher water use efficiency and fiber strength values were observed from trickle irrigated plots (***Sener, 1995***). ***Yazar et al. (2000)*** compared between trickle and LEPA irrigation of cotton with other irrigation methods such as sprinkler and furrow. They found that deficit LEPA and trickle irrigation of cotton generally reduced seed cotton yield. Both trickle and LEPA systems permitted precise control of the irrigation applications and provided uniform irrigations. ***Bange and Milroy (2000)*** demonstrated that cotton plants under full irrigation experienced increased vegetative growth, delayed maturity and reduced number of open bolls. ***Yazar et al. (2000)*** showed that K_c of cotton crop varies between 0.30 and 0.35 during initial growth to more than 1.0 at mid-growth, and then it falls below 1.0 at boll loading. It is a new irrigation technique, which requires that approximately half of the root system be always exposed to drying soil while the remaining half is irrigated as in full irrigation. The wetted and dried sides of the root system are alternated in a frequency according to crops, growing stages and soil water balance. This technique has the potential to reduce plant water use significantly, increase canopy vigour and maintain yields when compared with normal irrigation methods ***(Kang and Zhang, 2004).***

Zwart and Bastiaanssen (2004) reviewed the overall CWP of wheat, rice, maize and cotton crops experimental data and ascribed variability of crop water productivity (CWP) to climate, irrigation water management and nitrogen management. However, in reality CWP is likely to be significantly affected by soil texture and precipitation in addition to amount of irrigation water input. ***Aujla et al. (2005)*** evaluated the effect of various levels of water and N application through drip irrigation on seed cotton yield and water use efficiency (WUE). The results revealed that when the same quantity of irrigation water and N was applied through drip irrigation system, it increased the seed cotton yield to 2144 from 1624 kg/ha (an increase of 32%) under check-basin method of irrigation. The simulated results showed that by reducing the amount of irrigation water input below economic optimum, both the yield and ET of cotton and wheat crops were reduced and consequently crop water productivity (CWP) to varying magnitudes depending upon soil texture, precipitation and irrigation regimes. ***Daleshwar et al. (2006)*** conducted field experiments on a saline vertisols during 2000–2002 for evaluating the response of cotton (Gossypium hirsutum L.) to applied irrigation water (IW, 0.8, 1.0, 1.2 and 1.4 times the evapotranspiration, ET) with drip and furrow irrigation methods in four different blocks varying in soil salinity (ECe, surface 0.6m) and water table depths (WT). their results revealed that The crop responded to applied water and the maximum cotton yield (1.78 Mg ha^{-1} - average for two years) was obtained from block I (8.0 ± 0.4 dS m^{-1} soil salinity and, 1.25 ± 0.08 m water table depths) under drip irrigation applied at 1.2 ET while the lowest yield (0.18 Mg ha^{-1}) was from block IV (15.1 ± 0.8 dS m^{-1}

soil salinity and, 0.95 ± 0.07 m water table depths) when applied water equaled 0.8 ET with furrow irrigation. ***Taisheng et al. (2006)*** carried field experiment to investigate the effects of alternate partial root-zone irrigation on the yield and physiological responses of cotton. Their results suggest that alternate partial root-zone furrow irrigation (AFI) should be a useful water-saving irrigation method in arid region where cotton production is heavily dependent on irrigation and water resources are scarce. ***Jalota et al. (2006)*** studied the influence of soil texture, precipitation and deficit irrigation regime and their interactions on crop water productivity (CWP) for cotton and wheat crops. The simulated results showed that by reducing the amount of irrigation water input below economic optimum, both the yield and ET of cotton and wheat crops were reduced and consequently CWP to varying magnitudes depending upon soil texture, precipitation and irrigation regimes. With reducing post-sowing irrigation water from 300 to 75 mm, the decrease in CWP in silt loam, sandy loam and loamy sand soils were 15, 4 and 1% for cotton and 8, 36 and 55% for wheat, respectively, indicating higher decrease in CWP for wheat than for cotton, and in coarse textured than fine-textured soils. ***Necdet et al. (2006)*** carried out a field study during the 2003 and 2004 cropping seasons in the western Turkey to evaluate the effect of water deficit or water stress on crop yield and water use efficiencies for cotton and corn crops. Their results indicated that, the average seasonal water use values ranged from 174 to 558 mm in corn treatments and 257 to 867 mm in cotton treatment. The average corn grain yield varied from 2880 to 11340 kg ha^{-1} and average seed cotton yield varied from 1780 to 5490 kg ha^{-1}. Highest average corn and cotton yield were obtained from the full irrigation treatments. The average water use efficiency (WUE) ranged from 1.65 to 2.15 kg m^{-3} for corn and 0.61 to 0.72 kg m^{-3} for cotton, respectively.

The objective of the present research is to study the effect drip and furrow irrigation systems on cotton crop productivity.

MATERIAL AND METHOD

The present field experiments were carried out in the Experimental Farm of Faculty of Agriculture, Kafr El-Sheikh University, Kafr El-Sheikh during successive seasons 2003/2004 and 2004/2005. Each treatment consisted of four lines of cotton with a buffer strip of 1.5 m in between treatments to minimize the effects of lateral water. Cotton (Giza 89 variety, long-staple) was sown on April 4th and 2nd during 2003/2004 and 2004/2005 keeping spacing of 0.70 m between rows and 0.30 m between hills within the row. The cotton was harvested during September and October. Recommended package of other agronomic practices and plant protection measures were followed. Applied fertilizers equaled 34, 16 and 16 kg $fed.^{-1}$ of nitrogen, phosphorus and potash, respectively. Calcium Super Phosphate was added during seed-bed preparation at the rate of 100 kg fed^{-1}.The evapotranspiration was calculated to be 570 and 580 mm, respectively. The crop was irrigated with the available canal water (EC_w 0.41 dSm^{-1}) under furrow and drip irrigation. The lateral lines were laid parallel along each row, and the spacing of the 'online' emitters (4 L h^{-1}) along the lateral was 0.3 m. Water table depths were monitored weekly at the observation wells installed in the study area. Table 1 indicates some physical properties for different layers of experimental soil.

Table 1: Some physical properties for different layers of experimental soil.

Soil depth, cm	Particle size distribution, %			Soil Texture	Field capacity, %	Wilting point, %	Bulk density, g/cm^3
	Clay	Silt	Sand				
0 - 15	54.13	25.42	20.45	Clayey	44.90	23.70	1.09
15 - 30	52.00	25.84	22.16	Clayey	39.60	21.30	1.18
30 - 45	51.73	31.36	16.91	Clayey	38.30	20.60	1.28
45 – 60	48.20	33.51	18.29	Clayey	37.20	19.30	1.32
60 - 75	46.38	36.97	16.65	Clayey	36.10	18.40	1.37

Reference evapotranspiration (ET_0) of cotton was calculated using Cropwat Computer Program depending on the average climatic data according to modified Penman method. Climatic data were obtained from Sakha Weather Station for the growing period.

Irrigation water requirement:

Volumetric method was used to measure flow rate for furrow irrigation method. The time required to fill a known volume container (20 liters) was recorded. Also, the time required to reach the water to the end of the furrow was estimated for each treatment.

The irrigation water requirement for drip irrigation was calculated using the following equation according to ***FAO, 1980.***

$$IR_n = \frac{IR_n}{E_a} \quad \text{.....(1)}$$

Where:-

IR_g = irrigation requirements, mm d^{-1};

E_a = irrigation system efficiency (assumed 85%) and

IR_n = net irrigation requirements, mm d^{-1}

$$IR_n = ET_{cro} + L_r \quad \text{.....(2)}$$

Where:-

L_r = leaching requirements, mm d^{-1} (assumed 10%) and

ET_{crop} = crop water requirements, mm d^{-1}

$$ET_{crop} = K_c \times K_r \times ET_o \quad \text{.....(3)}$$

Where:-

K_c = crop factor (0.70 – 1.15 for cotton according to the growing period).

K_r = reduction factor (equals unity for field crops according to ***El-Ansary et al. 1999).*** and

ET_o = reference evapotranspiration mm d^{-1} which was calculated depending on climatic data.

Operation time for the different lateral lines was calculated as the relationship between irrigation requirements and emitter flow rate.

Treatments:

The present research included the following factors:

a) Irrigation system: Two irrigation systems were used (furrow and drip).

1- Furrow irrigation: Perforated pipes (PVC) 5 cm diameter was used with furrow irrigations. These perforated pipes were drilled with a 22 mm drill at 70 and 140 cm apart to use every row and alternative irrigation. Valves were used to control of pressure head and water flow rate. The inlet pressure was measured using pressure gauge. The irrigation intervals were every 18 days for traditional furrow irrigation and 12 days for alternative furrow irrigation.

2- Drip irrigation: The drip irrigation system consisted of main line from PVC, 5 cm diameter; submain line 2.5 cm diameter and lateral line made from PE 16 mm diameter. Built-in emitters (GR) were used with outlets spacing of 30 cm and 4 L h^{-1} flow rate. The irrigation intervals were every 3 days for drip irrigation.

Centrifugal pump with 3.68 kW (5 hp) gasoline engine was used for pumping the water with pressure head 26 m to the irrigation system. The pump was connected to the main line by flexible quick hoses.

b) Furrow and lateral line length:

Four different furrow and drip lines were used in the present study (20; 40; 60 and 80 m).

Soil moisture distribution:

Soil moisture is an important hydrologic state variable critical to successful hydroclimatic and environmental predictions. Soil moisture content influences the ability of land to hold additional water and thus affects groundwater levels and runoff. Adequate soil moisture is essential for plant growth; excesses and deficits of soil moisture must be considered in agricultural management practices. Soil moisture distribution in root zone under emitter along and across the lateral line in drip irrigation system was measured at different distances from emitter (0, 5, 10 and 15 cm) at different soil depths (0-15, 15-30, 30-45 and 45-60 cm). In case of traditional and alternative furrows, irrigation soil moisture content was measured at equal distances along the furrow (beginning, one fourth, middle, three fourth and end of the furrow) at different soil depths (0-15, 15-30, 30-45 and 45-60 cm). Soil samples were taken after 48 hour from irrigation using gravimetric method.

Leaf area index:

Leaf area index (LAI) is a powerful diagnostic of plant productivity. Despite the fact that many methods have been developed to quantify LAI, both directly and indirectly, leaf area index remains difficult to quantify accurately, owing to large spatial and temporal variability. Leaf area index drives both the within- and the below-canopy microclimate, determines and controls canopy water interception, radiation extinction, and water and carbon exchange. Area meter measuring set (LI-3100) was used to measure plant leaf area. Leaf area index (LAI) was calculated based on leaf area measurements and plant density obtained by counting the number of plants per 5-m row length. Leaf area index was calculated using the following equation according to ***El-Zeiny et al. (1989):***

$$LAI = \frac{Leaf\ area\ per\ plant,\ cm^2}{Accepted\ area\ per\ plant,\ cm^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(6)$$

Cotton yield

100 plants from each treatment were selected randomly and cotton yields were picked from these plants. The average cotton yield per plant was multiplied by number of plants per feddan (38000 plants) to get the total cotton yield in kentar per feddan.

Water use efficiency:

Water use efficiency is one of the most important criteria, where it is of greater practical importance. It is the ratio of cotton yield to the total amount of water. The highest value of water use efficiency means that less amount of irrigation water and highly cotton yield. Water use efficiency was calculated according to ***James (1988)*** as follows:

$$WUE = \frac{Y}{W_a} \times 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(7)$$

Where:-

WUE = water use efficiency, kg m^{-3};

Y = cotton yield, kg $fed.^{-1}$ and

W_a = total applied water, m^3 $fed.^{-1}$

<u>RESULTS AND DISCUSSION</u>

Total applied water

Excess water, early in the growing period, will restrict root and crop development. Cotton requires adequate water supply particularly just prior and during bud formation. Continued water supply during flower opening and yield formation periods results in prolonged and excessive growth and yield. Abrupt changes in water supply will adversely affect growth and cause flower and boll shedding. Severe water deficits during flowering may fully halt growth, but with subsequent water supply crop growth recovers and flower formation is resumed. The amount of irrigation water applied to the field was varied according to irrigation method and furrow length as shown in Table 2. Furrow irrigation method the amount of irrigation water was increased by about of 15.61% and 30.91% compared to alternate and drip irrigations, respectively. The average values of the total irrigation water that applied to cotton crop were 3090, 2608 and 2135 m^3/fed for furrow, alternative and drip irrigation, respectively. Increasing length of furrow and drip lines tended to increase total applied water. Also, increasing furrow length lead to receive more water (upstream) and other will receive less water (downstream). Too little water causes unnecessary water stress and can result in yield reductions. Too much water can cause water logging, leaching, and may also result in loss of yield. The results indicted that the amounts of applied water were 2420, 2557, 2677 and 2790 m^3/fed for 20, 40, 60 and 80 m furrow and drip line length, respectively. Using drip irrigation will be able to apply water in amounts and at rates sufficient to supply maximum ET demands and save more of irrigation water as shown in Fig. 1. The average values of saved water were 483 and 955 m^3/fed for alternate and drip irrigations, respectively compared to furrow irrigation method.

Water distribution and soil moisture content:

Water distribution was measured at different locations along furrow and drip lines. Adequate water supply is needed for vigorous growth, good budding and fruiting and for the formation of healthy bolls. Figure 2 indicates the water distribution along lateral line for drip irrigation system at different lateral lengths. Further along the line, led to a decline in the water distribution along the line and this is due to a decline in the quantity of water passing across section of lateral by increasing the distance from inlet. The best of water distribution was obtained with 20 m lateral line length

Table 2: The total irrigation water applied (m^3/fed) with different irrigation systems.

Irrigation system	Length of furrow and drip lines, m			
	20	40	60	80
Furrow	2930	3040	3150	3240
Alternate	2420	2550	2670	2790
Drip	1910	2080	2210	2340

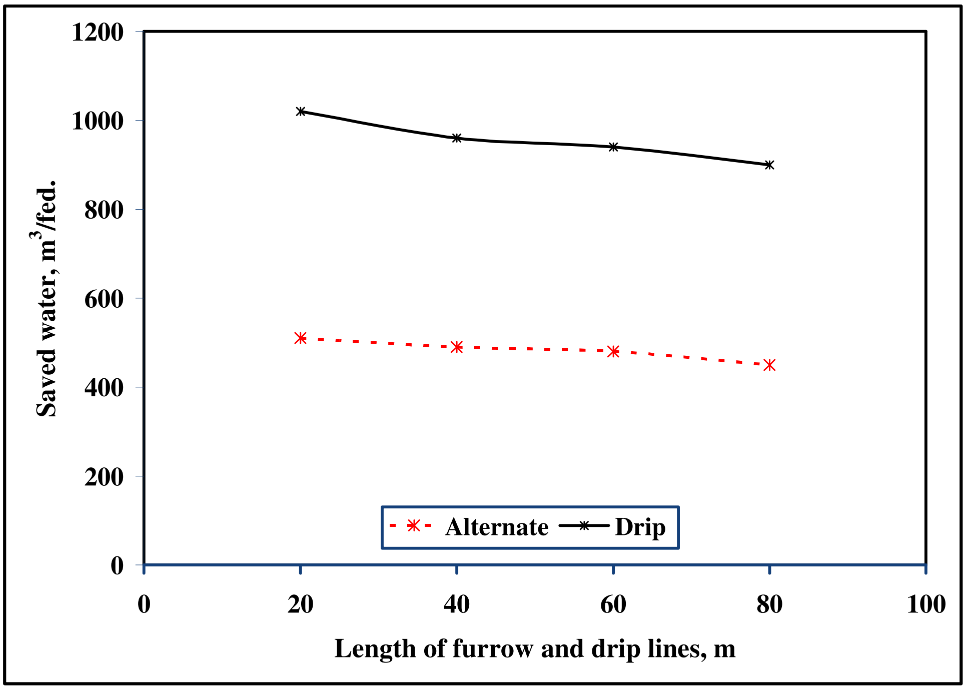

Fig. 1: Effect of furrow length and irrigation method on saving of irrigation water.

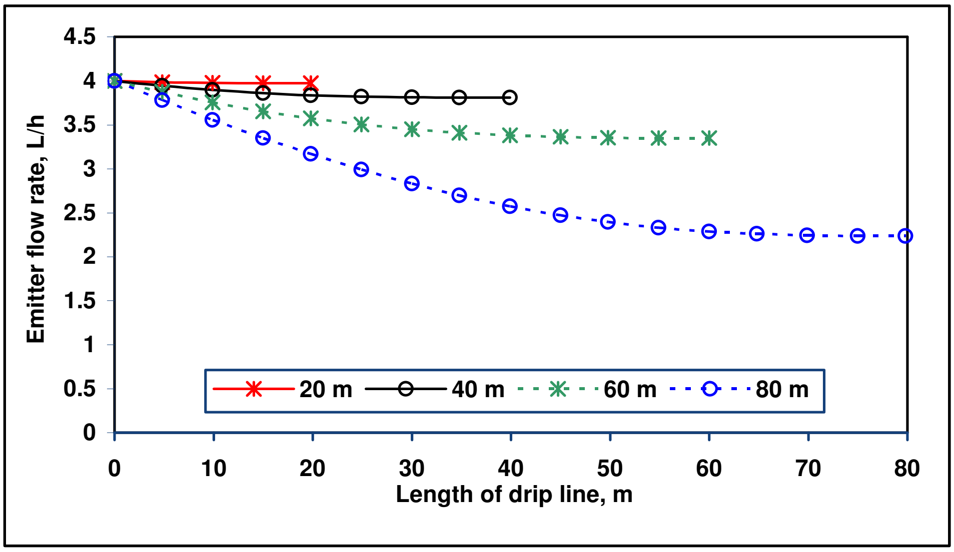

Fig. 2: Water distribution along lateral line for drip irrigation method.

The soil moisture distribution at different distances from the water source (emitter) in case of drip irrigation method on a 75-cm-deep heavy soil was measured and plotted in Fig. 3. The wetting front in the wettable soil spread out radially from the point source, with high moisture content underneath the point source. Evapotranspiration rates are strongly influenced by soil moisture content near the surface. Soil moisture distribution for traditional and alternate furrow irrigation was measured and plotted in Fig. 4. The results revealed that higher moisture content was measured at up stream of the furrow relative to its tail (downstream). Alternate irrigation method gave best soil moisture distribution compared to traditional furrow irrigation due to lateral water movement to the dry furrows during irrigation time.

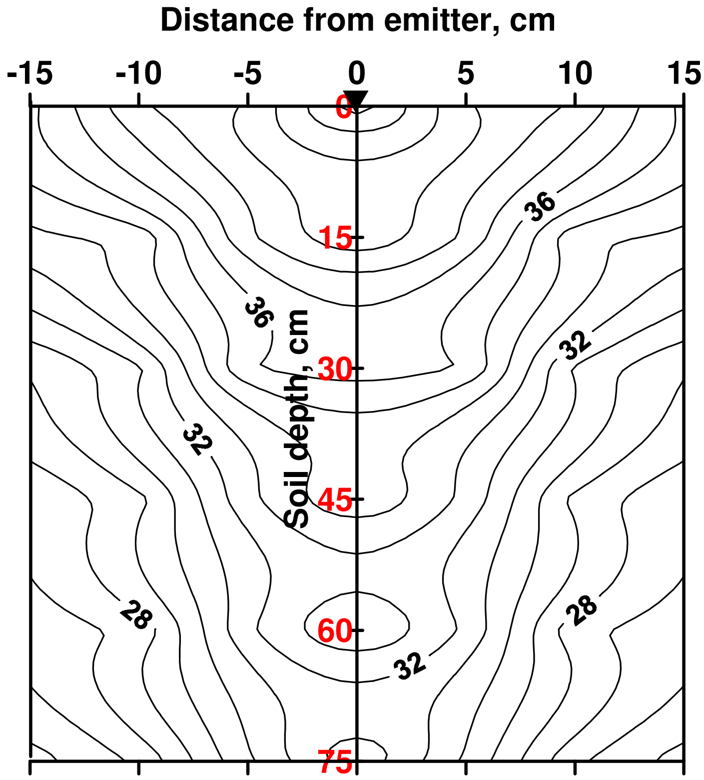

Fig. 3: Soil moisture distribution under emitter for different soil depths.

Leaf area index:

Leaf area indices differed little between length of furrow and drip lines but were strongly influenced by irrigation methods as shown in Fig. 5. Leaf area indices of the different treatments started to diverge early in the season, and the large differences between the treatments were found at early bloom to peak bloom. Maximum value of LAI was 6.13 obtained with traditional furrow irrigation at 100 days from planting date (near peak bloom) and 80 m furrow length. The average values of LAI were 3.05, 3.81 and 4.17 for drip, alternate and traditional furrow irrigation systems, respectively. The results showed that increasing furrow length tended to increase LAI with traditional and furrow irrigation methods, whereas the leaf area index increased by about of 12.41 % by increasing furrow length from 20 to 80 m. This outcome is due to that increased furrow length leads to increase the number of main-stem and branch leaves as well as the area of individual leaves and results increasing leaf area index. In case of drip irrigation system, the results indicted that the leaf area index decreased by increasing drip line length whereas the average values of LAI were 3.50, 3.30, 3.14 and 3.03 for 20, 40, 60 and 80 m drip line length, respectively. The results obtained in drip irrigation were because the distribution of irrigation water decreased by increasing drip line length. Also, the results indicated that increasing the amount of water added to the cotton crop (in case of furrow methods) tends to grow more vegetation growth.

Cotton yield:

Cotton yield was affected by the different irrigation methods and furrow lengths as shown in Fig. 6. Alternate irrigation method gave highest value of cotton yield compared to traditional furrow and drip irrigation methods. The average cotton yield values were 4.89, 5.69 and 4.93 Kantar/fed. for, traditional furrow, alternate furrow and drip irrigation methods, respectively. The highest value of cotton yield was 6.32 Kantar/fed obtained with alternative irrigation at 40 m furrow length. In general, increasing furrow and drip line length lead to decrease the cotton yield with traditional and drip irrigation methods. In case of alternate furrow irrigation, the results revealed that increasing furrow length from 20 to 40 m tended to increase cotton yield from 5.53 Kentar/fed. to 6.32 Kentar/fed. after that, increasing furrow length lead to decrease cotton yield.

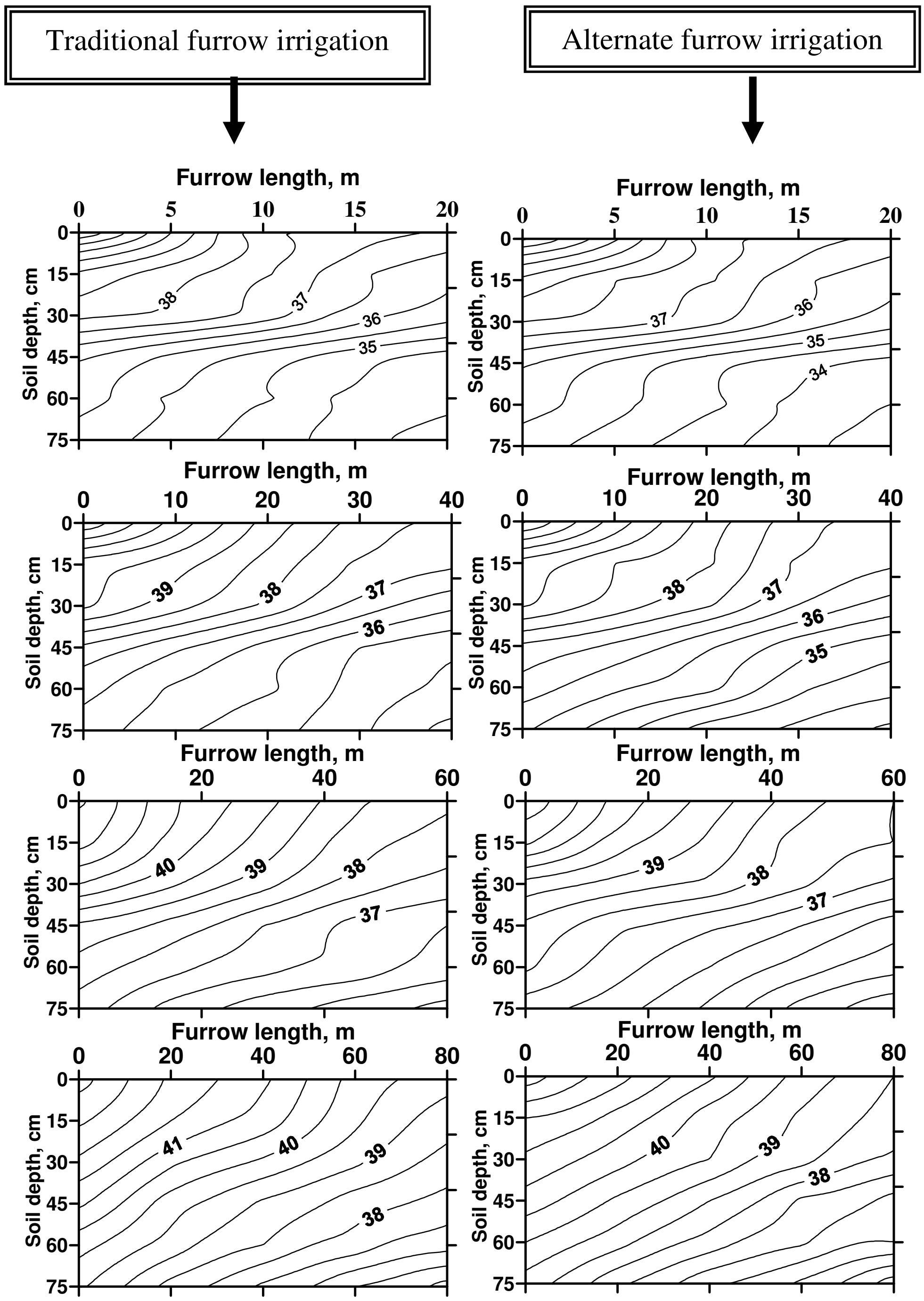

Fig. 4: Soil moisture distribution along furrow length at different soil depths for.

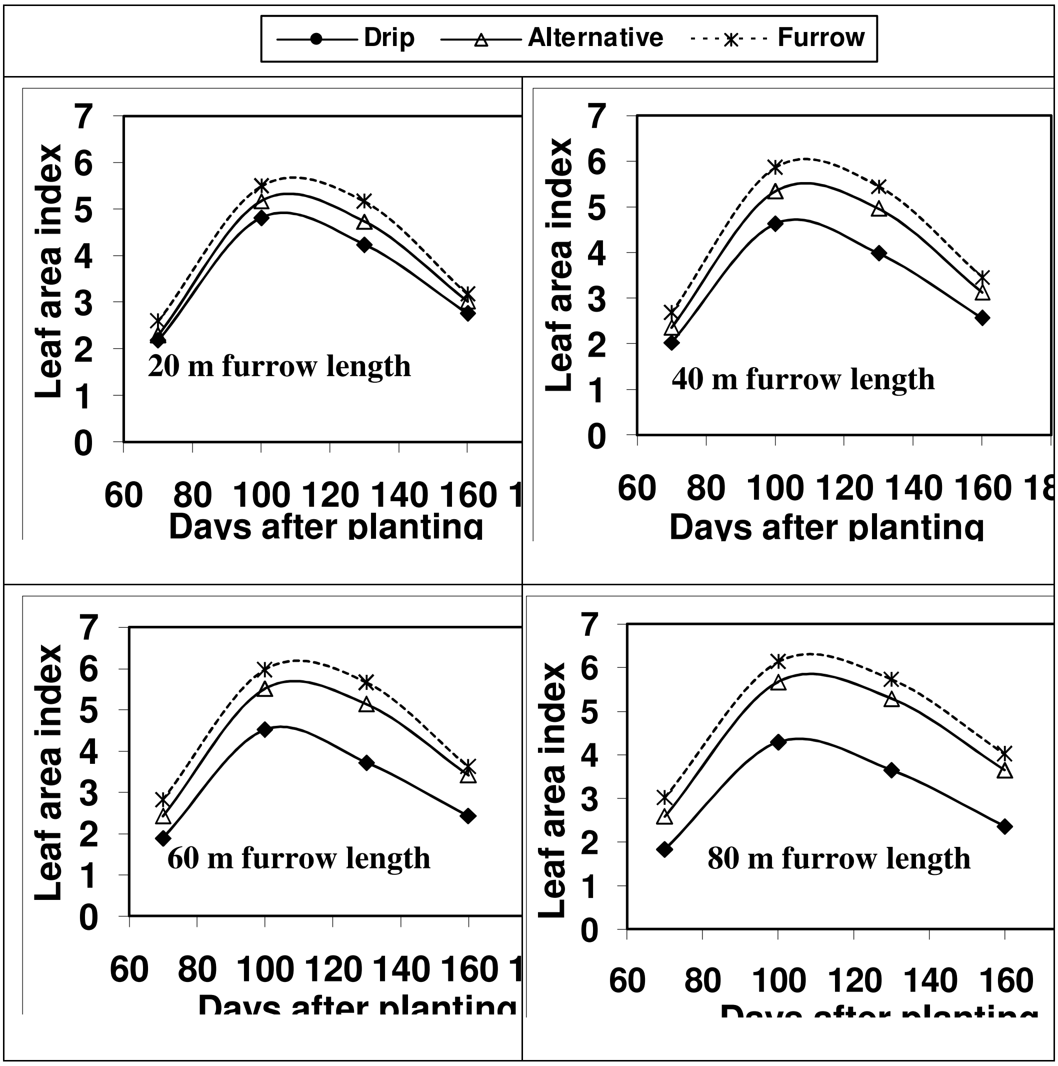

Fig. 5: Effect of irrigation methods and furrow length on leaf area index.

Water use efficiency:

The present work revealed that water use efficiency varied with irrigation methods and furrow lengths as shown in Table 3. The average value of water use efficiency varied from 0.29 to 0.21 kg/m^3 when furrow length changed from 20 m to 80 m with traditional furrow irrigation method. Increasing furrow and drip lines from 20 m to 80 m tended to vary water use efficiency from 0.36 to 0.29 kg/m^3 with alternative irrigation method and from 0.0.43 to 0.31 kg/m^3 with drip irrigation system. The maximum value of water use efficiency was 0.43 kg/m^3 using drip irrigation system and 20 m drip line length. The worst value was 0.21 kg/m^3 obtained with traditional furrow irrigation at 80 m furrow length. Drip irrigation system gave the greatest values of water use efficiency compared to other irrigation methods due to the amount of irrigation water applied with drip system was less than that added with traditional and alternate irrigation methods.

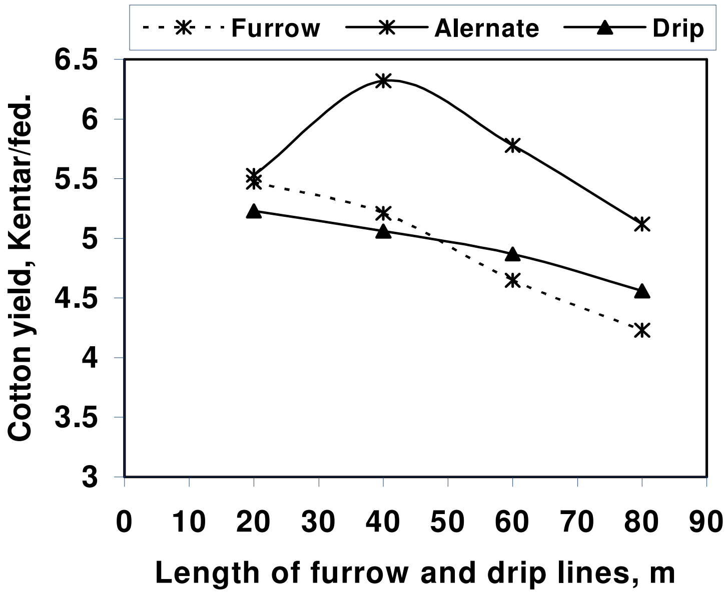

Fig. 6: Effect of irrigation methods and furrow length on cotton yield.

Table 3: Effect of irrigation methods and furrow lengths on water use efficiency (kg/m^3).

Irrigation system	Length of furrow and drip lines, m			
	20	40	60	80
Furrow	0.29	0.27	0.23	0.21
Alternate	0.36	0.39	0.34	0.29
Drip	0.43	0.38	0.35	0.31

Recommendations:

-Using drip system as irrigation method with cotton crop save amount of irrigation water and increases water use efficiency.

- The present research indicated that, 40 m furrow length gave best cotton yield in alternate irrigation method.
- Increasing furrow length tended to increase the amount of water added, which in turn leads to lack of productivity because the increase in the amount of water added leads to increase the vegetation growth and decreases in the growth of flowers.

REFERENCES

Ali, S.A. (1990). Efficiency of some experimental design of fertilization and irrigation experiments in Egyptian cotton. Ph.D. Thesis Fac. of Ag. Al-Azhar Univ. Egypt.

Aujla, M.S.; H.S. Thind and G.S. Buttar (2005). Cotton yield and water use efficiency at various levels of water and N through drip irrigation under two methods of planting. Agricultural Water Management 71 : 167–179.

Bange, M.P., S.P. Milroy, (2000). Timing of crop maturity in cotton-impact of dry matter production and partitioning. Field Crops Res. 68: 143–155.

Bucks, D.A.; S. G. Allen; R.L. Roth and B.R. Gardner (1988). Short staple cotton under micro and level-basin irrigation methods. Irrig. Sci. 9:161-176.

Camp, C.P.; W.M. Thomas and C.C. Green (1993). Microirrigation scheduling and tube placement for cotton in the southeastern Coastal Plain. Trans. of the ASAE 36 (4): 1073-1078.

Cetin, O., E. Ozyurt, and S. Sener, (1994). The effects of different irrigation methods on the yield and water use efficiency of cotton in Harran Plain. ICID 17th. European Regional Conf. on Efficient and Ecologically Sound Use of Ir. Water with Special Reference to European Countries. 16-22 May, Varna, Bulgaria,.

Daleshwar R.; M.V. Manjunatha ; G.R. Rajkumar ; M. Hebbara and P.S. Minhas (2006). Comparative effects of drip and furrow irrigation on the yield and water productivity of cotton (Gossypium hirsutum L.) in a saline and waterlogged vertisol. Ag. water manag. 8 3 (1): 30 – 3 6.

Doorenbos, J. and A.H. Kassam (1979). Yield response to water. FAO Irrigation and Drainage Paper 33, Rome, :193.

El-Ansary, M.Y.; M.A. Awad, M.N. El-Awady and H. El-Eryani (1999). Effect of drip irrigation uniformity on crop production. 7th Conf. of Misr Soc., Ag. Eng. 27-28 October.

El-Zeiny, H.A.; A.K. AbdEl-Halim and A.A. El-Noemani (1989). Response of maize to irrigation intervals under different levels phosphorous fertilization, Egypt, J. Appl. Sc., 4(4):1-11.

FAO, (1980). Irrigation and Drainage. Paper 36, Localized irrigation. Rome.

Grims, D.W. and K.M. El-Zik (1982). Water management for cotton. Univ. of California Bull. 1904.

Guinn, G. and J.R. Mauney. (1984). Fruiting of cotton. I. Effects of moisture status on flowering. Agron. J. 76:90-94.

Henggeler, J.C. (1995). A history of drip irrigated cotton in Texas. In Microirrigation for A Changing World. Proc. of 5th Inter. Microirrigation Congress. Ed F.R. Lamm. April 2-6, Orlando, Florida. ASAE Pub. : 669-675.

Jalota S.K.; Anil Sood; G.B.S. Chahal and B.U. Choudhury (2006). Crop water productivity of cotton (Gossypium hirsutum L.)–wheat (Triticum aestivum L.) system as influenced by deficit irrigation, soil texture and precipitation. Ag. water manag. 84 (1): 1 3 7 – 1 4 6.

James, L.G. (1988). Principles of farm irrigation system design. John Willy and Sons (ed.), N. Y. : 543.

Kang, S. and Zhang, J. (2004). Controlled alternate partial root zone irrigation: its physiological consequences and impact on water use efficiency. J. Exp. Bot. 55 (407): 2437–2446.

Mahrous, F. N. (1977). Effect of irrigation standards under some cultural practices of cotton growth and yield. Ph. D. Thesis, Fac. of Agric. Kafr El-Sheikh, Tanta Univ., Egypt.

Necdet D.; E. Yılmaz; F. Sezgin and T. Gürbüz (2006). Water-yield relation and water use efficiency of cotton (Gossypium hirsutum L.) and second crop corn (Zea mays L.) in Western Turkey. Agricultural Water Management 82 (1): 63 – 85.

Sener, S, (1994). The effects of water and energy saving irrigation methods on the yield and water use efficiency of cotton in Aegean Region and GAP Area. International Workshop on New Ag. Technologies: Low Input Sustainable Ag. Methods. 14-15 July, 1994 TUBITAK-Marmara Res. Center, Gebze, Istanbul.

Taisheng D.; K. S. Kang; J. Zhang; F. Li and X. Hub (2006). Yield and physiological responses of cotton to partial root-zone irrigation in the oasis field of northwest China. Ag. Water Manag. 84 (1): 41 – 52.

Wilson, P., H. Ayer, and G. Snide. (1984). Drip irrigation for cotton: Implications for farm profits. Agric. Econ. Rep. 517. USDA, Washington, DC.

Yazar, A.; S. M. Sezen, and S. Sesveren (2000). LEPA and trickle irrigation of cotton in the southeast Anatolia Project (GAP) area in Turkey. Options Me´diterrane´ennes B series, 31: 133– 149.

Zwart, S.J., and W.G.M. Bastiaanssen (2004). Review of measured crop water productivity values for irrigated wheat, rice, cotton and maize. Agric. Water Manage. 69: 115–133.

<u>الملخص العربي</u>

أنتاج محصول القطن باستخدام طرق ري مختلفة

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أجريت التجارب الحقلية بالمزرعة البحثية – كلية الزراعة بكفر الشيخ – جامعة كفر الشيخ خلال موسمي ٢٠٠٤/٢٠٠٣ و ٢٠٠٥/٢٠٠٤ . وقد استخدم قطن طويل التيلة صنف جيزة ٨٩ و تمت الزراعة في ٤ ابريل في الموسم الأول و ٢ ابريل في الموسم الثاني. وكانت المسافة بين الخطوط ٧٠ سم و المسافة بين النباتات في الصف الواحد ٣٠ سم. وكان الهدف من هذا البحث هو دراسة تأثير الري بالتنقيط و الري السطحي بالخطوط على إنتاجيه محصول القطن.

و اشتملت الدراسة على العوامل التالية :-

٣- نظم الري : تم استخدام ثلاث طرق للري في هذه الدراسة هي: الري بالتنقيط ، الري بالخطوط العادية (التقليدية) ، الري بالخطوط التبادلية.

٤- طول الخطوط : وقد تم استخدام أربعة أطوال مختلفة هي ٢٠ – ٤٠ – ٦٠ – ٨٠ متر.

وكانت أهم النتائج المتحصل عليها هي :-

- أوضحت الدراسة أن كمية المياه المضافة كانت ٣٠٩٠ - ٢٦٠٨ - ٢١٣٥ متر^{3}/فدان و ذلك للري بالخطوط التقليدية – الري التبادلي و الري بالتنقيط على الترتيب. كما أوضحت النتائج أن استخدام الري التبادلي و الري بالتنقيط أدى إلى توفير في مياه الري بمقدار ٤٨٢ و ٩٥٥ متر^{3}/فدان مقارنة بالري بالخطوط التقليدية.
- أدى زيادة كل من طول الخطوط في الري بالخطوط والري التبادلي و كذا طول الخطوط الفرعية في الري بالتنقيط إلى انخفاض توزيع مياه الري على طول الخط.
- وجد من التجارب أن أقصى قيمة من دليل مساحة الأوراق (LAI) كانت ٦,١٣ تم الحصول عليها مع طريقة الري بالخطوط التقليدية عندما كان طول خط الري ٨٠ متر وذلك عند ١٠٠ يوم من تاريخ الزراعة.
- أوضحت النتائج أن استخدام الري بالتنقيط أدى إلى تحسن كفاءة استخدام مياه الري .
- متوسط محصول القطن المتحصل عليه كان ٤,٨٩ - ٥,٦٩ - ٤,٩٣ قنطار/فدان وذلك لطرق الري : الري بالخطوط التقليدية – الري التبادلي – الري بالتنقيط على الترتيب .
- أقصى قيمة لكفاءة استخدام مياه الري كانت ٠,٤٣ كج/متر^{3} وذلك عند استخدام الري بالتنقيط بطول خطوط فرعية ٢٠ متر بينما كانت أقل قيمة لكفاءة استخدام مياه الري ٠,٢١ كج/متر^{3} باستخدام الري بالخطوط التقليدية بطول ٨٠ متر.

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