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ENHANCING THE IRRIGATION WATER MANAGEMENT USING DEVELOPED IRRIGATION CANALS

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ABSTRACT

Water shortages have economic, technical, social, cultural, physical, hydroclimatic and political dimensions. Since irrigation outstrips all other sectors in its use of water, crop production would be the first area to suffer when water supplies are inadequate. The present research aims to study the effectiveness of the developed irrigation canal on irrigation water management and compare its performance with the traditional ones. Field experiments were located in the middle northern part of the Nile Delta (Kafrelsheikh Governorate) during the two successive seasons of winter (2005/2006) and summer 2006. To fulfill the intended objective, several factors are studied as follow: i) One improved canals named Dakalt canal used as the main source of water, ii) Six improved meskas and three different locations (Head, middle and tail), iii) One unimproved meska was selected on Dakalt canal, and iv) Six cultivated areas (fields) on each meska were selected. The obtained results indicated that the minimum operating time and minimum amount of applied water were recorded for improved meskas, as compared with the unimproved one. The maximum value of applied water was recorded for berseem and rice crops during winter and summer season, respectively. It can be concluded that the improved meskas achieved the high values of water saving while they were 1079.8, 1023.4, 1240.7, 1019.3, 1028.6 and 1129.7 m^3/ feddan for long berseem crop comparing with unimproved meska. Also, the amounts of saved water were 14.8, 12.6, 14.3, 9.8, 10.6 and 12.3 % for rice crop under the previous meskas, respectively, during summer season compared with unimproved meska.

The maximum and minimum total dynamic head of 4.744 and 3.543 m were recorded for pumps in meskas Om-Sen and Edrega El-Bahria (A), respectively. The average values of applied irrigation efficiency for developed meskas had higher values than undeveloped meska for different crops. Based on the recorded results, it can be observed that the developed irrigation canals have many advantages such as: Saving irrigation water, hence minimize the drainage problems, improve the usage efficiencies, equity of water distribution, minimum cost and high crop yields. Utilization of developed canals has increased the conveyance efficiency to more than 90%, irrigation water efficiency to 70% and high remarkable crop yield. Therefore, it is recommended to utilize the developed canals for irrigation water conveyance in the Delta region, especially the pipe line canal.

INTRODUCTION

Water has been recognized as a basic human right. Large quantities of fresh water are required in many parts of the world for agricultural, industrial and domestic uses. Drought and desertification are increasing significantly, involving wider and wider areas of the planet. About 97% of the earth's water is salty and rest is fresh water. Less than 1% fresh water is within human reach. Despite, technological progress, renewable fresh water reserves on earth will be only 0.3% of the world water. Agriculture uses two-third of available fresh water.

Water scarcity, which occurs not only in arid regions, may be characterized as a mismatch between water supply and water demand. Over a billion people worldwide lack access to sufficient water of good quality. Most of these people live in Asia and Africa. The growing population causes a steady rise in the living standards leads to increase the specific water consumption per capita.

Abou El-Fatoh and Ali (1998) illustrated that efficiency of field water use, water distribution, and irrigation application were improved as a resulted of the implementation effect of irrigation improvement project (IIP). A better irrigation distribution through reducing different irrigation losses was found under implementation of developed meskas through IIP at Mania, Beny Sweef, Kafrelsheikh and Damanhour (Saleh, 1999). Also, using gated pipeline, as an advanced surface irrigation, had slightly decreased basic infiltration rate as compared to traditional surface irrigation under maize crop. A lot of benefits had been achieved throughout the IIP in Egypt on the scale of main system and field irrigation system. The high conveyance efficiency, and over all field irrigation efficiency, which means minimum water losses, enhance water saving and improving soil characteristics. Welson (1999) came to the same conclusion.

Hussein *et al.* (1999) revealed that irrigation efficiency, water distribution and crop water use efficiency for developed meskas were higher than undeveloped one for all different crops.

Okasha (2002) concluded that irrigation efficiency under improved meskas PVC, pipeline and the concrete canal were higher than that under unimproved one (the earth canal). Also, concluded that the yields of crops (wheat, clover, maize and cotton) were increased under improved meskas compared to unimproved one. PVC pipeline and concrete canals produced the highest crop yields, while the earth canal produced the lowest yields.

Irrigation improvement project –IIP- (2003) reported that the crop yields had increased significantly and is above the targets at the onset of IIP under improved irrigation than unimproved one at Kafrelsheikh Governorate. Abo Soliman *et al.* (2006) pointed out that the conveyance losses in earth marwas were ranged from 14.89 to 21.05 %. IIP (2003) was one of the attempts by Ministry of Water Resources and Irrigation to implement more effective farm irrigation technologies. IIP was also introduced to face the converting to the free market policy in agricultural in last decade in Egypt. Liberalizing cropping patterns requires a corresponding change in irrigation strategies to meet the real crop water needs. Water deliveries must be changed to a demand system in order to accommodate the different needs of individual crops. This is the main concept of introducing IIP according to Martin (1995).

Egypt depends on the Nile River as a main source; about 85 % of Egypt share from water (55.5 Billion cubic meter) is used in the agricultural sector. It is difficult to increase this share but there is possibility to improve the irrigation efficiency, decreasing the water losses and improve the irrigation system. These are considered the main elements in achieving the national aim for increasing irrigation efficiency and the equality in water distribution among the peasants. Consequently these give the chance to maximize the agricultural production. Also peasants should face the water deficiency and avoid the extravagance of irrigation water.

The lack of potable water poses a big problem in remote and arid regions. Pollution and exploitation of ground water aquifers and surface water have led to a decrease of quantity and/or quality of available natural water resources in many regions.

Unprecedented commitment on a global scale to innovate new water technologies and management systems will be required to: i) preserve the quality of our current supplies, ii) reduce the demand for water through gains in efficiency, and iii) increase the overall quantity of freshwater available.

Different studies have proved that there are no alternatives related to water management at the level of the field because the total irrigation efficiency ranges from 40 to 50 percent. Hence it is possible to achieve good irrigation management at the field level. In another meaning, decreasing the field irrigation losses that happen during the irrigation processes. Losses like, water distribution losses at the level of marwas or meskas (The non-efficient ditches or meskas) that can be attributed to the grass, the big part and irregularity the slope of the sector.

The present study aims to study the effectiveness of developed irrigation canals that can be used to enhance the irrigation water management and compare its performance with the traditional ones. The performance was evaluated through studying several variables such as, water usage efficiency, conveyance efficiency, equality of water distribution, wastes of irrigation water, energy savings, reducing the irrigation time and crop production.

MATERIALS AND METHODS

Field experiments site was located in the middle northern part of the Nile Delta (Kafrelsheikh Governorate) during the two successive seasons of winter (2005/2006) and summer 2006. It has elevation of about 6 meters above sea level. To conduct the experiments, one main irrigation canal named as Mit Yazid which located in Kafrelsheikh was selected. Also, Dakalt canal was selected as sub canal from Mit Yazid canal which scene about 5481 Feddan with length of about 11.400 km as shown in Fig. 1.

1 Parameters of study

Several factors were considered in the present study to evaluate effectiveness of the developed canals on the irrigation water management, and they are as follow:

1.1 Meska type:

An **i**mproved Dakalt canal was selected. Six improved Meskas at different locations addition to one unimproved meska were selected on Dakalt canal as indicated in Table 1. Six cultivated areas (fields) in each meska were selected.

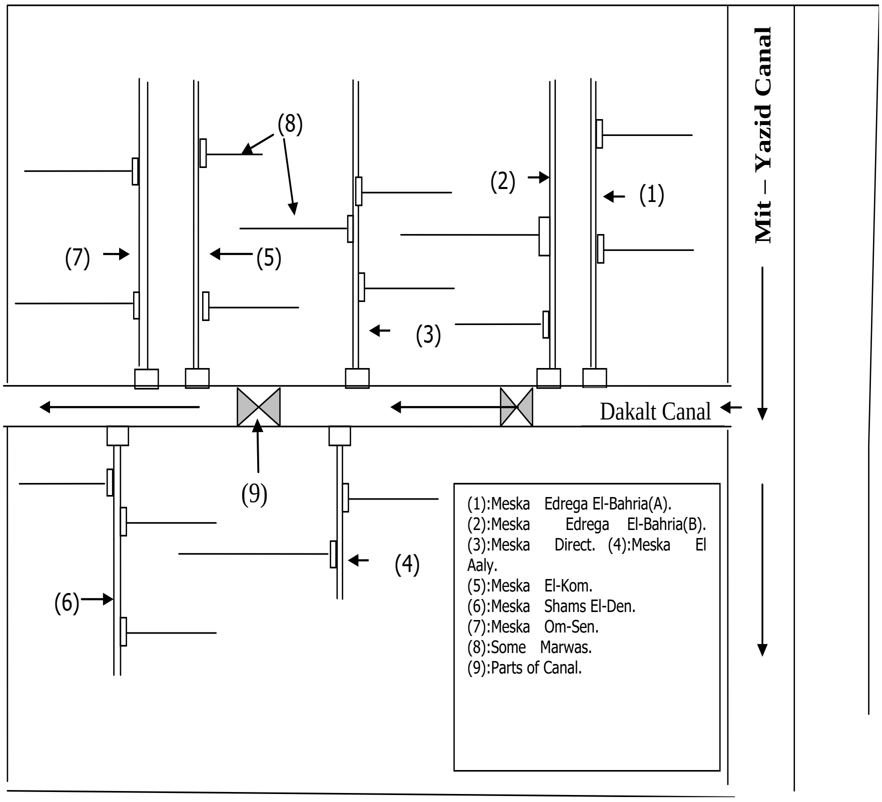

Fig. 1: Schematic diagram of the selected experimental site.

Table 1: Survey for selected Meskas on Dakalt canal.

Mit-Yazid sub-project							
Given code*	**Meska name**	**Location on Dakalt canal**	**Distance form Dakalt canal inlet, km**	**Position of Meska on Dakalt canal**	**Served area, fed.**	**Meska type**	**Length of Meska, m**
Improved meskas							
1	Edrega El-Bahria (A)	Head	1.81	Right	73.1	Pipeline	1025
2	Edrega El-Bahria (B)		1.91	Right	105.5	Pipeline	1441
3	Direct	Middle	4.18	Right	62.2	Pipeline	754
4	El Aaly		4.26	Left	47.0	Raised line	362
5	El Kom	Tail	7.75	Right	69.2	Raised line	948
6	Shams El-Den		8.26	Left	65.3	Pipeline	1171
Unimproved meska							
7	Om Sen	Tail	7.85	Right	235.3	Earthen	1679

***In the rest of the current study, given codes will be used instead of the names.**
Note: source of water for all Meskas was taken from Dakalt canal.

There are two improved methods such as PVC pipelines and raised line (J –Section) used in the present study. Four pipelines meskas of about 40.5 cm diameters were used and buried under the ground at depth ranged from 80-120 cm. There is a stand at the beginning where water is lifted to it by pumps. All of these lines were irrigated through valves sited at the head of each Marwa. Irrigation water was delivered from Dakalt canal into the Meskas using different pumps putted at irrigation stations and operated at normal speed. The characteristics of different pumps were presented in Table 2. Fig. 2 shows sectional elevation view of pipe line meskas layout.

Two J- section meskas were used. These like the lifted meskas up to the ground and lined with ordinal concrete shaped like J. The water is lifted to the meskas using pumps. The irrigation water comes through holes located at the head of each marwa. Fig. 3 shows sectional view of raised line meskas layout. Fig. 4 shows the layout of one unimproved meska (earthen meskas) that selected on Dakalt canal.

Table 2: Standard case of different pumps at selected Meskas on Dakalt canal.

Meska code	Pumps type	No. of pumps	Pumps location on Meska	Pump discharge (Q), L/s	Motor		Fuel consumption, L./hr	Manufa. and installation year
					Speed rpm	operating head (TDH), m		
		1	Head		1200	4.95	1.00	
1	Kerloskar	1	Head	60	1500	4.95	1.00	1984
		1	Head		1500	4.95	1.00	
		1	Head		1800	4.90	1.25	
2	Kerloskar	1	Head	90	1500	4.90	1.25	1984
		1	Head		1500	4.90	1.25	
3	Kerloskar	1	Middle	90	1500	4.45	1.00	1984
		1	Middle	60	1800	3.45	1.25	
4	Kerloskar	1	Middle	60	1800	3.50	1.00	1984
		1	Middle		1800	3.50	1.00	
5	Dutez	1	Tail	90	1800	3.60	1.25	2000
		1	Tail	60	1800	3.45	1.00	2000
6	Kerloskar	1	Tail	90	1800	3.60	1.25	1984
		1	Tail		1800	3.36	1.25	
7	Local coll	1	Tail	30	1200	3.25	1.00	1982
	Local Ind.	1	Tail	45	1500	3.50	1.25	1984
	Kerloskar	1	Tail	30	1200	3.25	1.00	1986
	Super Ma.	1	Tail	55	1600	4.50	1.25	2002
	L.Zakaze.	1	Tail	45	1500	4.00	1.25	1999
	Wailer	1	Tail	30	1200	3.25	1.00	1994

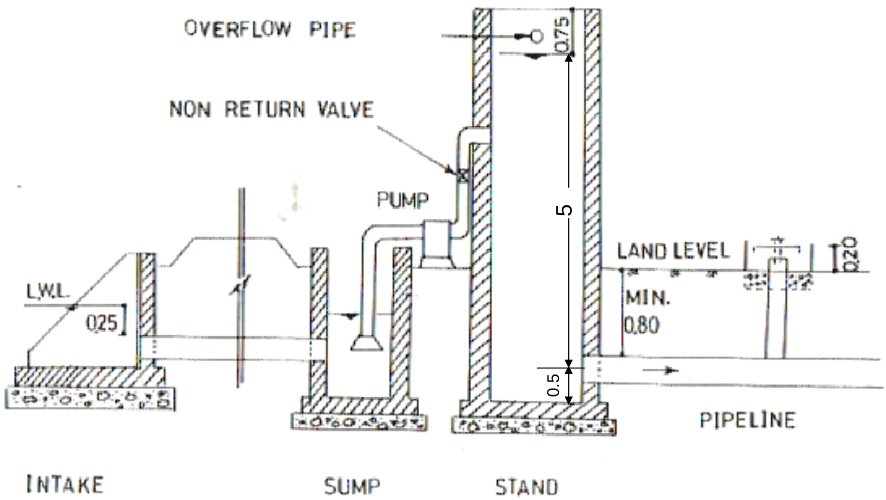

Fig. 2 Sectional elevation of pipe line Meskas layout -Dimension in m- IIP (2003).

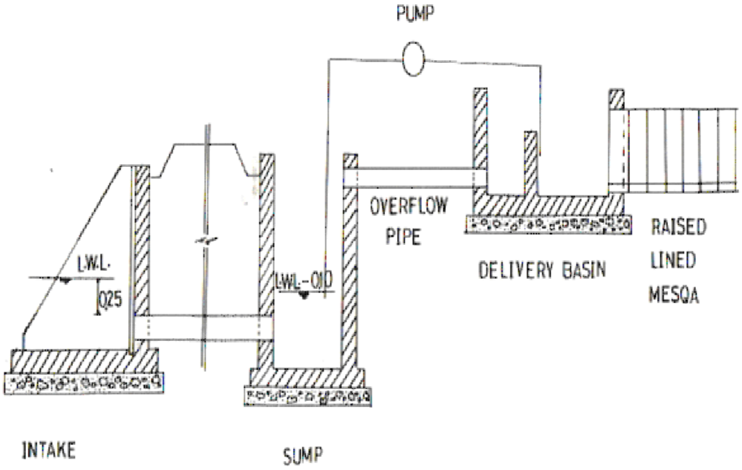

Fig. 3: Sectional view of raised line meskas layout -Dimensions in m- IIP (2003).

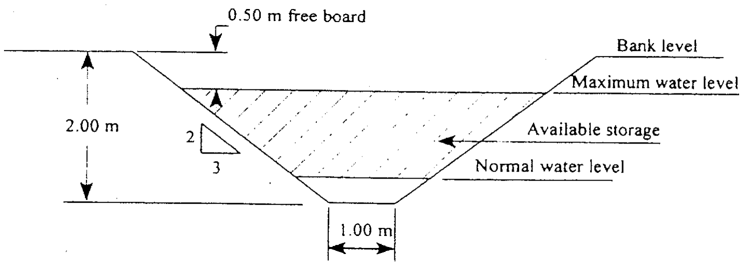

Fig. 4: Layout of an earthen meskas.

1.2 Crop type: Seven different types of crops were used during two seasons, winter (2005/2006) and summer 2006. The details of these crops and its water requirements were presented in Table 3.

Table 3: Cropping area (feddan) and its water requirements, for selected meskas on Dakalt canal during winter 2005/2006 and summer 2006

Meska Code		Winter season 2005/2006					Summer season 2006		
		Sugar beet	Wheat	Berseem		Bean	Rice	Cotton	Maize
				Short	Long				
1	Cropping area, fed.	11.8	28.2	22.0	8.1	3.0	73.1	0.0	0.0
	W. R.*, m^3/ area.	51613	31678	22608	32127	4603	410757	0.0	0.0
2	Cropping area, fed.	6.3	59.9	33.0	6.3	0.0	59.5	30.5	15.0
	W. R.*, m^3/ area.	109633	47515	17584	17152	0.0	334336	102760	44269
3	Cropping area, fed.	18.5	17.6	20.0	6.5	0.0	31.6	24.0	7.0
	W. R.*, m^3/ area.	32213	28797	18142	50368	0.0	177564	80861	20659
4	Cropping area, fed.	8.8	16.5	15.0	6.0	0.7	28.0	18.0	1.0
	W. R.*, m^3/ area.	30199	21598	16746	23959	1228	157335	60646	2951
5	Cropping area, area.	11.0	32.3	20.2	3.0	11.0	40.0	20.0	10.0
	W. R.*, m^3/ area.	59117	29085	8373	29949	50640	224764	67384	29512
6	Cropping area, fed.	19.6	23.1	14.0	8.0	0.0	42.2	16.1	7.0
	W. R.*, m^3/ area.	42279	20158	22329	53363	0.0	237126	54244	20659
7	Cropping area, fed.	22.25	95.8	82.0	28.5	6.75	121.5	78.9	34.9
	W. R.*, m^3/ area.	175339	118067	79546	60578	10357	682721	265830	102998

*** W. R. = Water requirement**

2 Measurement of different parameters

2.1. Soil properties: Table 4 shows some physical properties of soil under investigation which was determined according to Black (1965).

Table 4. Some physical properties of the experimental soil study.

Sampling sector depth (cm)	Particle size distribution %			Texture class	Bulk density, kg/ m^3.	Field capacity, % (wb)	W.P., % (wb)
	Sand	Silt	Clay				
0< 15	21.54	26.64	51.82	clay	1200	46.9	25.49
15< 30	21.55	26.91	51.54	clay	1290	39.72	21.59
30< 45	20.53	25.76	53.71	clay	1370	38.00	20.65
45< 60	20.40	26.48	53.12	clay	1470	35.48	19.28
Mean	21.00	26.45	52.55	-	1330	40.02	21.75

2.2 Water discharge: The pumps discharges were measured using Ultrasonic Flow Meter with reflective type V in case of developed Meskas. In V type, the transducers were coupled with data logger and mounted on one side of the pipe. The water discharge is recorded in l/s. The Ultrasonic Flow Meter is suitable for developed Meskas, while there are some difficulties when used with undeveloped Meskas. For undeveloped Meska, the pumps discharges were measured using the flume. In this method, the discharge is based on the water level on upstream and downstream of the cut-throat flume during the measuring time as pointed out by Michael (1978). The discharge can be obtained from the corresponding tables based on the coefficient that is calculated using the following equation:

$$C = \frac{H_a - H_b}{H_a} \qquad (1)$$

Where**:** C = discharge coefficient, dimensionless,

H_a= the upstream water head, cm and

H_b=the downstream water head, cm.

2.3 Total dynamic head (TDH): Pumping head was measured using pressure gauges installed on discharge pipes. TDH is the summation of the suction head, delivery head, loss of head in pipe due to friction and loss of head at outlet due to velocity and estimated using Eqn. 2 (Ismail, 2001-Arabic reference):

$$H_m = H_s + H_{fs} + H_d + H_{fd} + \frac{v_d^2}{2g} \qquad (2)$$

Where: H_m = manometer head, m,

H_s = suction lift, m,

H_{fs} = suction head loss due to friction in pipe and fittings, m,

H_d = delivery lift, m,

H_{fd} = delivery head loss due to friction in pipe, m and

V_d = water velocity in the delivery pipe, m/s and can be calculated using the following equation (Ismail, 2001-Arabic reference):

$$V_d = \frac{Q}{\frac{\pi}{4} x D^2} \qquad (3)$$

Where: Q = discharge, $m^3/s.$, and

D = inner diameter of the delivery pipe, m.

The friction losses during suction and delivery can be calculated using the following friction equation (Ismail, 2001-Arabic reference):

$$H_f = \frac{1.212 x 10^{10} L}{D^{4.87}} x \left[\frac{Q}{C}\right]^{1.852} \qquad (4)$$

Where: H_f = the friction losses, m,

L = the length of pipe, m,

D = inside pipe diameter, mm,

Q = flow rate or discharge, l / s, and

C = Hazen Williams friction coefficient, dimensionless.

and C = 100 and 50 for steel age of 15 years and leather (hose), respectively.

2.4 Pumps power requirements: The work performed by a pump is a function of the total head and the weight of the liquid pumped in a given time period. The power added to water as it moves through a pump can be calculated with the following formula (Kraatz 1977).

$$P = \frac{wQ H_m}{const.\ \eta} \quad (5)$$

Where: P = pumps power requirement, kW,
ω = water specific gravity,
Q = discharge, m^3/s,
H_m = total dynamic head, m. and
η = pump efficiency (take 0.85)

2.2.5 Applied irrigation water: Applied water per feddan consists of total pumped water and the rainfall during winter season. Total pumped water is calculated from Eqn (6) based on the calibrated values of discharges and the operation time (Eid, 1998):

$$W_A = q \times t \times n \quad (6)$$

Where: W_A = applied irrigation water, m^3/fed,
q = pump discharge, m^3/min,
t = total irrigation time, min/fed, and
n = number of irrigations per season.

The meteorological data during the two growing seasons of study are presented in Table 5.

Table 5: Monthly mean values of some meteorological data at Kafrelsheikh province during the two growing seasons (Sakha Meteorological Station).

Winter(2005/2006)					
Months	**Air temperature °C**		**Relative humidity, %(mean)**	**Wind velocity, km/day**	**Rainfall, mm/month**
	Max.	**Min.**			
Oct.	28.10	13.80	66.27	96.83	10.0
Nov.	24.18	9.42	61.74	73.70	27.0
Dec.	21.23	7.45	75.00	60.30	35.0
Jan.	19.50	5.30	76.30	48.43	27.0
Feb.	20.50	7.29	74.65	69.72	66.0
Mar.	23.93	9.17	75.80	103.37	7.0
April	20.06	9.33	61.84	91.00	91.0
May	23.75	12.50	65.75	113.00	0.0
Summer 2006					
June	31.7	17.0	68.15	117.00	0.0
July	31.3	17.5	71.55	80.00	0.0
Aug.	33.97	19.27	75.50	66.80	0.0
Sep.	33.0	16.8	69.50	76.00	0.0
Oct.	29.0	13.4	62.75	70.00	16.0

2.6 Water stored (W_s): Calculations of W_s were reported for all irrigations until harvesting date using the following equation:

$$\left[W_s = \sum_{i=1}^{n=4} d_i X D_b \frac{(\Theta_2 - \Theta_1)}{100} \right] \quad (7)$$

Where: W_s = Amount of water stored , cm^3,

Θ_2 = Soil moisture content % after irrigation (on dry weight basis),

Θ_1 = Soil moisture content % before irrigation (on dry weight basis),

N = number of soil layers (4 layers)

D_b = Bulk density in g/cm^3 and

d_i = Depth of soil layer.

2.7 Water use effectiveness (W_{UE}): Water use effectiveness is one of the most important criteria, where it is of greater practical importance. Water use efficiency is the ratio of crop yield to the total amount of water. The highest value of water use efficiency means that less amount of irrigation water and highly crop yield. It was measured according to James (1988) as follows:

$$W_{UE} = \frac{Y}{W_a} x\,100 \qquad (8)$$

Where: W_{UE} = water use effectiveness, kg/m^3

Y = total yield, kg/fed, and

W_a = total applied water, m^3/fed.

2.2.8 Water conveyance efficiency: Conveyance efficiency was calculated according to Doorenbos and Kassam (1979) using the following equation:

$$\text{Conveyance efficiency} = \frac{\text{Water applied to the field}}{\text{Cross water requirement}} x\,100 \qquad (9)$$

2.9 Cost analysis: The impact of water crisis on the economy of the developing countries has been severe. The growing demand for water and minimizing its losses which are required for economic growth has created the need to search and develop alternative irrigation canals for the growing population.

Pumping cost per feddan is defined for four different crops; berseem and wheat during winter and rice and cotton during summer. Two indicators are used for calculating the costs in the present study.

i) Cost of pumped unit of water: this indicator was calculated as the ratio between total cost and total pumped water

ii) Irrigating cost per unit area: this indicator is calculated as the ratio between total cost and area that cultivated by a specific crop.

- Total cost was calculated by estimating both fixed and operating costs. The useful life of raised line and pipeline meskas were considered to be 15 years and 20 years, respectively.

Costs were cited from commercial prices of Egyptian market during the year (2005/2006). Calculation of costs was in L.E (US $ =6.65 L.E in the study period).

2.9.1 Fixed cost:

2.9.1.1. Annual depreciation: It is calculated for tractor, pump, and irrigation network components as follows:

$$\text{Annual depreciation} = \frac{\text{Prime machine price - Price at the end of expected operating life}}{\text{Expected life, years}} \quad (10)$$

Price of the machine at the end of operating life is assumed to be 10**%** of the main price.

2.9.1.2. Interest and investment: Interest ratio was assumed as 13**%.** The following formula was used to calculate interest costs (El- Dnasoury, 2001, Arabic reference).

$$\text{Interest costs} = \text{Interest ratio} \times \frac{\text{Main price} + \text{price at the end of life}}{2} \quad (11)$$

2.9.1.3. Taxes, insurance and shelter: These were assumed as 2**%** of the main machine price **(El- Dnasoury, 2001,** Arabic reference**).**

2.9.2. Operating costs:

2.9.2.1. Fuel: Fuel cost was calculated using the following simple equation (Kepner *et al.*, 1982)

Fuel cost (L.E. /h) = Fuel consumption rate (l/h) x Fuel price (L.E. /l) **(**12**)**

2.9.2.2. Lubrication: Oil and lubrication costs were assumed as 15**%** of the fuel cost according to Kepner *et al.* (1982)

2.9.2.3. Repairs and maintenance: Repairs and maintenance costs were assumed as 100% of annual depreciation cost (El- Dnasoury, 2001).

2.9.2.4. Labor: Labor cost is based upon prevailing wage rates. The labor charge was taken as 3 L.E./h (Ismail, 2002, Arabic reference).

Statistical analysis

The recorded data was analyzed to determine the performance and economics of the developed irrigation canals and compare its performance with the undeveloped ones under the specified conditions. The recorded data were analysed statistically, using excel to determine the variance and correlation coefficients. The economics of the investigated systems was determined by annual cost method and the mean values were compared by L.S.D. test.'

RESULTS AND DISCUSSION

1 Amount of Applied and Saved Water:

1.1. Amount of applied water:

The results showed that, the pump discharges are varied due to maintenance of the pumps from the previous years, worker experience and operating time of each pump. It was found that, the amounts of water applied for sugar beet crop were 2868.5, 2815.1, 2836.5, 2922.8, 2902.5. 2825.3 and 3481.6 m^3/ fed. season under meskas Edrega El-Bhria "A", Edrega El-Bhria "B", Direct, El Aaly, El Kom, Shams El-Den and Om Sen, respectively . While they were 6548.7, 6722.7, 6585.4, 6933.2, 6873.5, 6745.3 and 7687.6 for rice crop for the previous meskas, respectively. The recorded data revealed that the amount applied water using undeveloped meskas was more that amount applied by using developed meskas under different operating conditions and for all the crops under investigation.

The lowest value of operating time per feddan of about 8.65 h/season was obtained during winter season in case of Edrega El- Bhria "B" (improved meskas). While the maximum value of 29.22 h/season was recorded with Om- Sen (unimproved meska).

Figures 5 and 6 show the effect of Meska type on average applied water for different crops. The maximum value of applied water was recorded for Berseem and rice crops during winter and summer season, respectively.

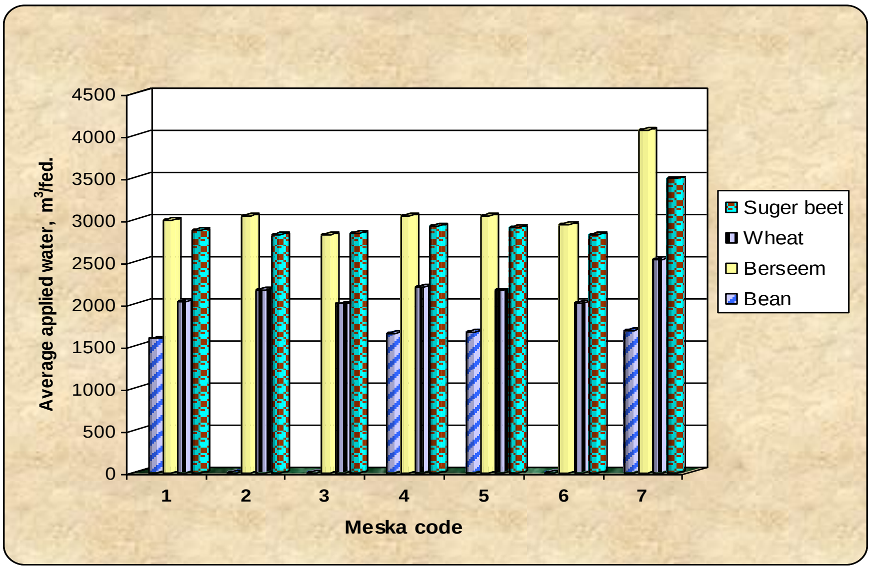

Fig. 5: Effect of Meska type on average applied water for winter crops.

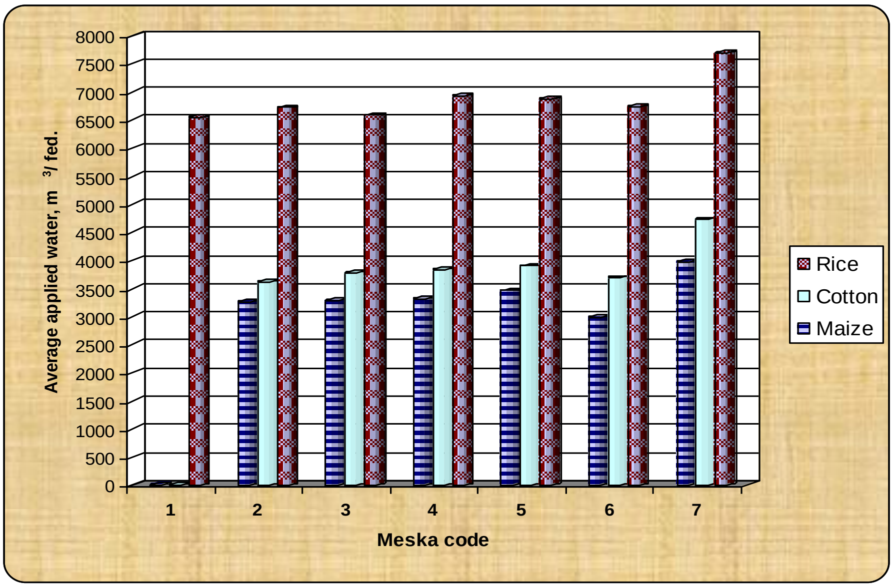

Fig. 6: Effect of Meska type on average applied water for summer crops.

Om- Sen (meska 7- considered as control Meska) gave the highest value of applied water for all treatments during winter as well as summer season, because earthen Meska had higher advance time and lower water advance speed, more seepage losses. These results are in agreement with Junejo (1993). The most important advantage of developed irrigation systems is due to abounds in irrigation water at the tail end of irrigation canals and consequently no additional use of drainage water for irrigation (Saleh, 1999).

1.2 Amount of saved water

Figures 7 and 8 show the effect of Meska type on average saved water for different crops during winter and summer, respectively. It was found that the average values of saved water of sugar beet crop were 613.1, 666.5, 645.1, 558.8, 579.1 and 656.3 m^3/fed for improved meskas 1, 2, 3, 4, 5 and 6, respectively compared with traditional irrigation unimproved (Earthen meska). While these values were 496.2, 355.4, 521.1, 328.5, 365.0 and 504.2 m^3/fed, for wheat crop in case of same conditions aforesaid.

It can be concluded that the improved meskas achieved the high values of water saving which they were 1079.8, 1023.4, 1240.7, 1019.3, 1028.6 and 1129.7 m^3/fed for long berseem crop comparing with unimproved meska. This is because longer irrigation time in unimproved meska due to decrease of discharge as a result of increased deep percolation, run off, infiltration, seepage and evaporation, in agreement with Abou El-Fatoh and Ali, (1998) and Welson, (1999).

It is obvious that the quantity of saved water by improved meskas is more than that of unimproved one. The amounts of saved water were 14.8, 12.6, 14.3, 9.8, 10.6 and 12.3 % for rice crop under the previous meskas, respectively, compared with unimproved meska. While, they were 1102.8, 941.4, 892.8, 822.5 and 1039.7 m^3/fed with cotton crop for 2, 3, 4, 5 and 6 meskas, respectively.

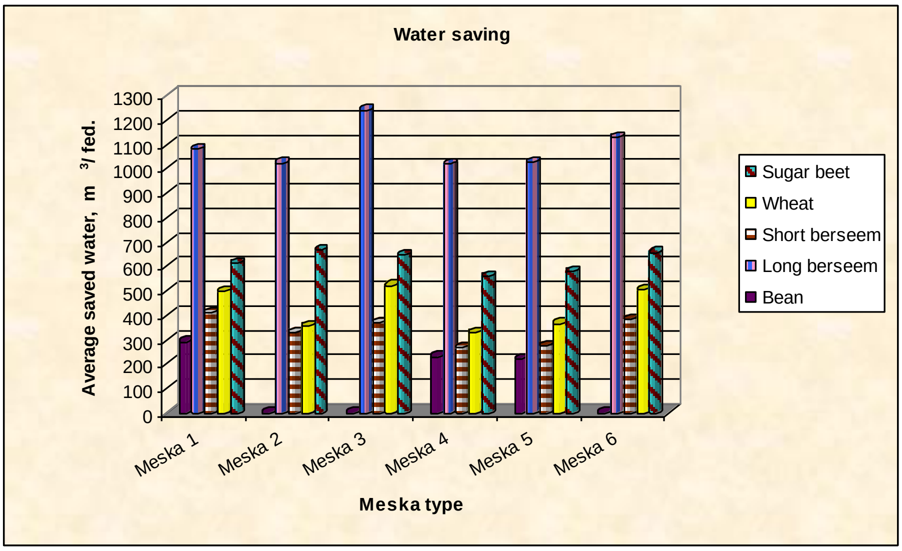

Fig. 7: Effect of meska type on average saved water for winter crops.

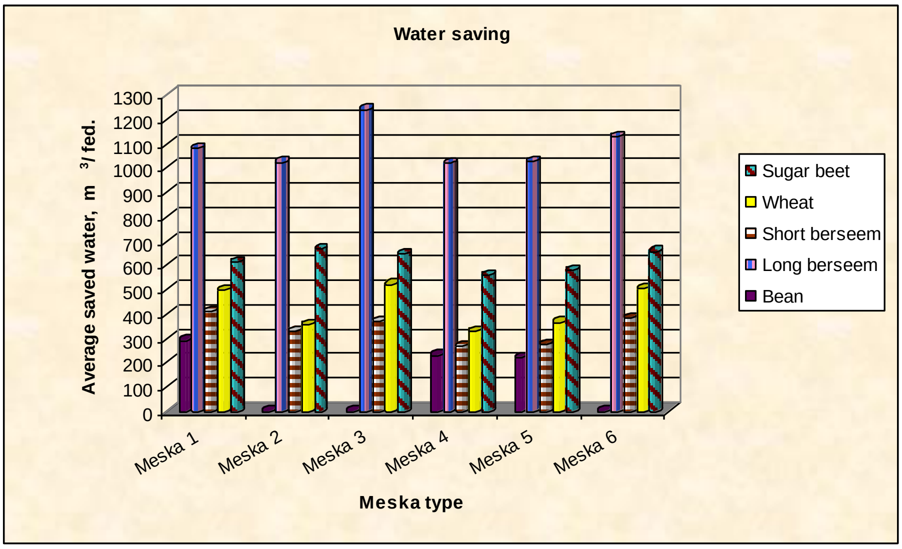

Fig. 8: Effect of meska type on average saved water for summer crops.

3.2 Water consumptive use for different crops

Data revealed that the mean values of water consumptive use (W.C.U.) were 1633.55, 1098.15, 863.9, 1674.64 and 920.62 m^3/fed. For sugar beet, wheat, short berseem, long berseem and bean crops, respectively.

Fig. 9 shows W.C.U for summer crops during growing season 2006. The total W.C.U values were 2988.66, 2021.5 and 1770.75 m^3/fed for rice, cotton and maize, respectively.

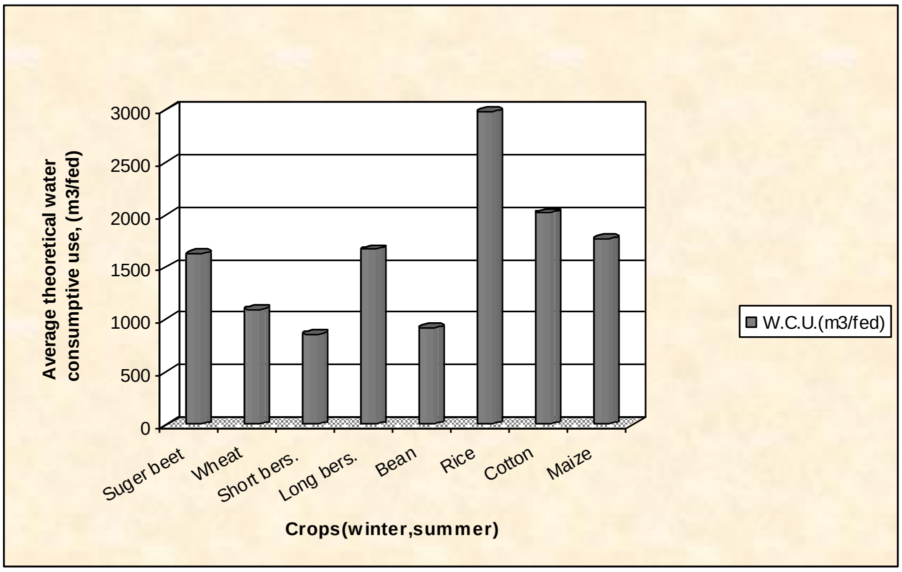

Fig. 9: Crop water consumptive use for selected meskas during winter 2005/2006 and summer 2006.

3 Crop water requirements (C.W.R)

Figs.10 and 11 show the effect of meska type on water requirements for winter crops and summer crops, respectively. It was found that using unimproved meska tended to increase crop water requirements by about 842 and 739 m^3/fed. season compared with pipe line and raised line, respectively, in case of sugar beet crop. Also, the average values of C.W.R. increased by about 29.6, 31.4, 31.7 and 31.4 % for wheat, short berseem, long berseem and bean that irrigated using Om- Sen meska compared with pipe line meska. The C.W.R values increased by about 22.0, 28.7, 28.7 and 28.6 % for the same crops that irrigated using Om- Sen meska compared with raised line meskas.

The results showed that the values of crop water requirements were 4598, 4860 and 5942 m^3/fed under pipe line; 2925, 3168 and 4177 m^3/fed. season under raised line, and 2515, 2724 and 3445 m^3/fed. season under Earthen meskas for rice, cotton and maize, respectively.

It can be concluded that the lowest value was recorded with pipeline meskas because the high irrigation efficiency in pipeline meskas. During winter season, the rainfall of 75 mm ranged from 11 to 17% of the total applied water in different meskas.

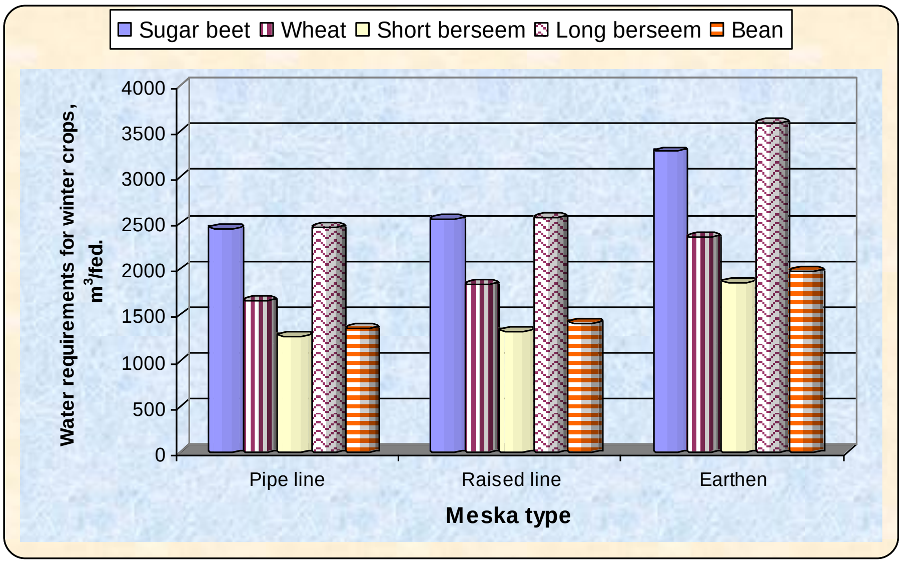

Fig.10: Effect of meska type on water requirements for winter crops during 2005/2006.

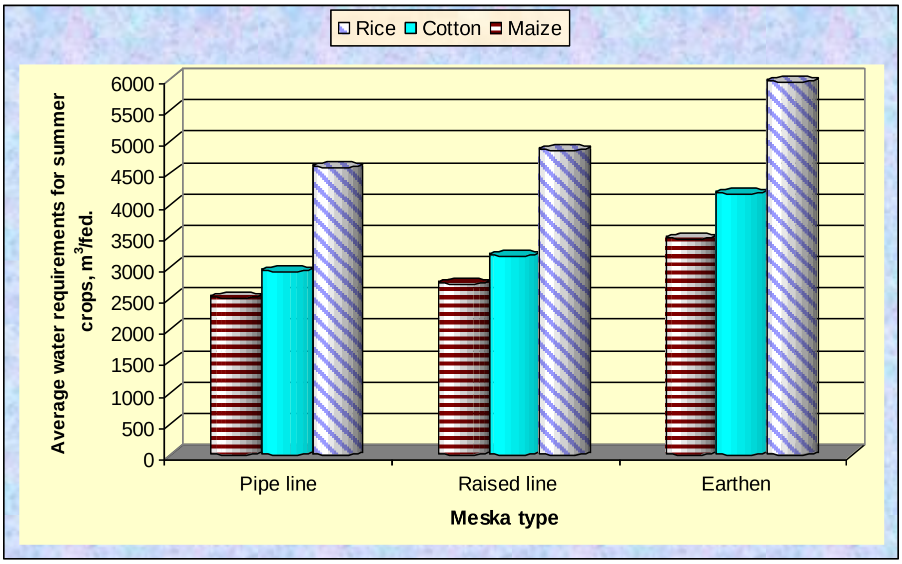

Fig.11: Effect of meska type on water requirements for summer crops during 2006.

4 Irrigation Efficiencies

Table 6 shows the average conveyance efficiency, water consumptive use efficiency and water utilization efficiency for selected crops at different meskas on Dakalt canal. The recorded data revealed that, the average values of water conveyance efficiency were 96.13, 95.60, 95.18, 92.57, 92.82, 94.98 and 84.57 % for meska 1, 2, 3, 4, 5, 6 and 7, respectively. These results are in agreement with those obtained by EWUP (1984), Salah (1999), Mahmoud, 2005 and Abo Soliman *et al.* (2006)). The average values of water use efficiency were 1.99, 2.25, 2.29, 2.09, 2.06, 2.26 and 1.39 kg/m^3 for meska 1, 2, 3, 4, 5, 6 and 7, respectively.

The improved meskas achieved the highest value of water conveyance efficiency. It was found that the applied irrigation efficiency for developed meskas had higher values than undeveloped meska for all different crops. The data showed the pipeline meskas achieved the highest values of irrigation efficiencies comparing with the raised line and earthen meskas.

5 Pumping performance

5.1 Total dynamic head (TDH)

TDH is the total head that the pump must overcome to move water or it represents the net work done on a unit weight of fluid as it passed through the pump. The TDH for the purpose of a pump test would be the (Pumping water level + Discharge head). Table 7 shows the average calibration data for measured total dynamic head (TDH) of the selected pumps at normal speed on Dakalt canal and pumps power requirements.

It was found that, the highest TDH value of 4.744 m was recorded for pump in meska 7. While the lowest value of 3.543 m was recorded for pump in meska 1. This may be attributed to the decrease of water level and increase of frication due to narrowness suction and delivery pipes. The results indicated that, pressure difference increased by increasing operating pressure head for different water levels. This may be due to increase different losses caused by increasing operating pressure head.

Table 7: Effect of meska type on the total dynamic head, discharge and the pumps power requirements for selected meskas.

Meska code	Discharge, m^3/s.	TDH, m	Brake horse power, kW (hp)	Power requirement, kW (hp)
1	0.04291	3.543	7.059 (9.6)	5.824 (7.92)
2	0.05997	3.764	8.820 (12.0)	8.272 (11.25)
3	0.05209	4.216	8.530 (11.6)	7.412 (10.08)
4	0.04320	3.895	7.060 (9.60)	6.015 (8.18)
5	0.04291	3.687	6.360 (8.65)	5.882 (7.99)
6	0.03592	3.778	5.220 (7.10)	4.956 (6.74)
7	0.02882	4.744	4.530 (6.20)	4.251 (5.78)

6 Pumping cost per unit of water

Pumping cost is an important indicator to distinguish between improved and unimproved systems. The cost of a pumping water unit consists of initial cost, fuel consumption cost, oil consumption cost, operating cost (maintenance & repairing costs), and labour cost.

The average values of each component for network irrigation at both seasons were calculated and the most effective component is the labour cost during summer season. During winter season, seasonal fixed cost is slightly higher than labour cost. Oil cost and maintenance & repair are the minimum cost during winter season, in agreement with *Santosh* (1976). Table 8 shows the average cost of pumped unit of water for selected meskas under investigation.

The average cost of a water unit for selected meskas on Dakalt canal during winter and summer is illustrated in Fig. 12. It can be observed that meska 6 gave the best average cost of a water unit compared to the other meskas during summer season. While, the highest value of water unit cost was given by meska 7 (undeveloped one).

Table 8: Average cost of a water unit for selected meskas on Dakalt canal during winter (2005/2006) and summer 2006.

Meska code	Average cost, L.E/m^3	
	Winter 2005-2006	Summer 2006
1	0.049	0.022
2	0.037	0.024
3	0.032	0.023
4	0.041	0.035
5	0.039	0.023
6	0.043	0.021
7	0.079	0.063

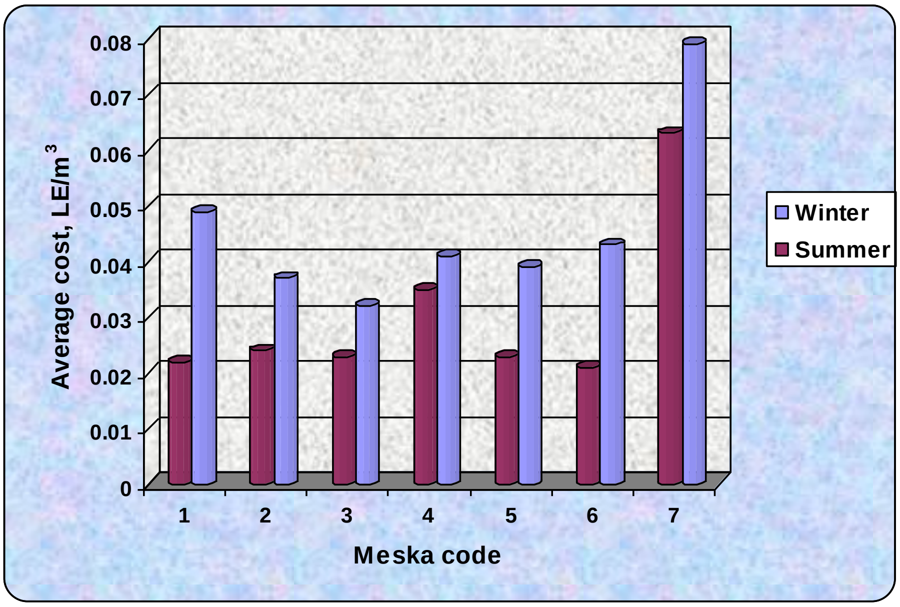

Fig.12: Effect of meska type on the average cost of a water unit during winter 2005/2006 and summer 2006.

The results indicate that, the maximum value of average cost was 0.079 LE/m^3, which recorded during winter season at meska 7. The average cost of water unit in summer season decreased compared with winter season, due to the highest amount total pumped water in summer due to specific cultivated crops which case rice. It is clear that both of improved and unimproved meskas has lower cost during summer comparing with winter. The recorded results indicated that, labour cost is the most effective component, especially for rice crop. This increase of labour cost for rice crop is due to the increase of total irrigation time for this crop. During winter season, oil cost is the least effective cost.

7 Crops yields

The results revealed that the improved meskas achieved the highest yields in comparison with unimproved one. Generally, it can be noticed that the improved meskas increased the yield by about 24.16, 25.22 and 20.01 % for sugar beet, wheat and berseem crops, respectively. These increment values were 30.92, 27.55 and 24.45 % for rice, cotton and maize crops, respectively.

Concerning the type of improved meskas, Tables 9 and 10 presented the effect of improvement of meskas on crops yields. It was noticed that, sugar beet yield increased by about 27.0 and 18.6 % in case of pipeline and raised line, respectively compared to earthen meska. In the same manner, wheat crop increased by about 29.9 and 21.8 % at the same condition. But in case of berseem crop the increasing values were 22.3 and 15.4 %, respectively. While it was noticed that, rice yield increased by about 32.1 and 28.9 % in case of pipeline and raised line, respectively compared to earthen meska. In the same manner, cotton crop increased by about 30.3 and 23.4 % at the same condition. But in case of maize crop the increasing values were 25.0 and 24.1 %, respectively.

Based on the above discussion it can be concluded that the pipeline gave highest values of productivity, water saving and irrigation efficiencies.

Table 9: Effect of meska type on average crops yields during winter 2005/2006 .

Types of meskas		Sugar beet		Wheat		Berseem	
		Yield, Mg/ fed.	increment, %	Yield, Ard./ fed.	increment, %	Yield, Mg/ fed.	increment, %
Improved meskas	Pipe line meskas	24.94	27.0	23.53	29.9	4.45	22.3
	Raised line meskas	23.31	18.6	22.58	21.8	4.20	15.4
Unimproved meska	Earthen meska	19.65	-	18.54	-	3.64	-

Table 10: Effect of meska type on average crops yields during summer 2006.

Types of meskas		Rice		Cotton		Maize	
		Yield, Mg/ fed.	increment, %	Yield Ken*/ fed.	increment, %	yield Ard. / fed.	increment, %
Improved meskas	Pipe line meskas	4.20	32.1	9.80	30.3	24.88	25.0
	Raised line meskas	4.10	28.9	9.28	23.4	24. 69	24.1
Unimproved meska	Earthen meska	3.18	-	7.52	-	19.9	-

*** ken = 157.5 kg,**
Ard = 150 kg

Conclusion

Large quantities of fresh water are required in many parts of the world for agricultural, industrial and domestic uses.

- The recorded data revealed that the amount applied water using undeveloped meskas was more that amount applied by using developed meskas under different operating conditions and for all the crops under investigation.
- The quantity of saved water by improved meskas is more than that of unimproved one.
- The comparison results indicated that the lining process or canal improvement can save amount of water more than 1000 m^3 per fed per year. Therefore, the yearly saving water would be more than $8x10^9$ m^3 as national level from the total water used in the agricultural sector; hence the saved water can be directed to other land cultivation or other agricultural projects.
- The average of earthy canals is 2 m width but after improving canals it would be 0.96 m depth, so it will provide part of the area that can be added to the farm land about 0.52 % from the total area (which almost 52 feddan per 10000 feddan).
- It can be concluded that the pipeline gave highest values of productivity, water saving and irrigation efficiencies. Therefore it is recommended to use the type of improved pipeline.

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تحسين إدارة مياه الري باستخدام قنوات الري المطورة

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نظرا للزيادة المطردة في عدد السكان يتطلب ذلك كميات كبيرة من الماء العذبِ في العديدِ مِنْ أجزاءِ العالمِ للاستعمالات المحليةِ والصناعيةِ والزراعيةِ. نقص المياه لَه أبعادُ سياسيةُ وطبيعيةُ وثقافيةُ واجتماعية وتقنيةُ اقتصادية. منذ أن تجاوزْ الرَيَّ كُلّ القطاعات الأخرى في استعمالها مِنْ الماءِ، لإنتاج المحاصيلِ سيكون قطاع الري من أولي القطاعات تأثيرا بنقص إمداد المياه.

أهداف الدراسةِ : دِراسَة فعالية قناةَ الرَيِّ المطورةِ على تحسين إدارةِ ماءِ الرَيِّ ومقارنة أدائَها بالوحدةِ التقليديةِ.

لذلك أجريت التجربة الحقلية بمنطقة دقلت التي تقع في الجزء الشمالي المتوسط لدلتا النيل- محافظة كفر الشيخ أثناء الفصلين المتعاقبين شتاء ٢٠٠٦/٢٠٠٥ وصيف ٢٠٠٦ م.

ولتحقيق الأهداف تم دراسة المتغيرات الآتية:

- تم استخدام ترعة دقلت كمصدر أساسي للري
- تم استخدام ستة (٦) مساقي مطورة موزعين ٢ (اثنين) عند كل من رأس، وسط وذيل الترعة
- منها ٤(أربعة)مساقي أنبوبية(مدفونة) و ٢ (اثنين)مبطنة (مرفوعة)
- مسقي ١ (واحدة) ترابية (غير مطورة) عند ذيل الترعة
- ٦ (ستة) مناطق مزروعة (حقول) في كل مسقي.

بالنسبة للري المطور تم استخدام طلمبات للري ذات تصرفات أعلي موضوعة عند رأس المسقي داخل غرفة تسمي غرفة المأوي، واستخدم في الري التقليدي طلمبات الري العادية تجميع محلي وتم تشغيل الجميع عند السرعة الطبيعية وكل المساقي أخذت مياهها من ترعة دقلت.

أشارتْ النَتائِجُ إلي:

- كان أقل وأقصي زمن تشغيل للطلمبات لوحدة المساحة تم قياسه في المساقي المطورة وغير المطورة علي التوالي.
- كانت أقصي كمية مياه مضافة مضافة بالنسبة لمحصولي البرسيم والأرز خلال فصلي الشتاء والصيف علي التوالي وكان ذلك في مسقي أم سن الترابية . وكميات المياه المتوفرة كانت ٢٣٢٤ و ١٩٦٥ م^{٣} / فدان بالنسبة لمساقي الأنابيب المدفونة والمساقي المبطنة المرفوعة، علي التوالي أثناء موسم الشتاء مقارنة بالمسقي الترابية. بينما كانت المياه المتوفرة حوالي ٢٦٢١ و ٢٣٥٩ م^{٣} / فدان ،علي التوالي بالنسبة للمسا قي سالفة الذكر خلال فصل الصيف. وكان إجمالي الاستهلاك المائي والاحتياجات المائية تغُيّرتْ مِنْ محصولِ إلى آخرِ وأيضاً مِنْ موسم إلى الآخرِ.
- حققت المسقي رقم ٧ (الترابية) أعلي متطلبات مائية بينما حققت المساقي المطورة أقل متطلبات مائية للمحاصيل الشتوية والصيفية علي التوالي.

وجد أن أقصي وأقل قيمة للضاغط الديناميكي الكلي هي 4.744 و 3.543متر بالنسبة للطلمبات علي المسقي الترابية (٧) والمسقي المطورة رقم (١) علي التوالي.

- المسقي ٦ أعطت أفضل تكلفة متوسطة لكل وحدة مياه مقارنة بالمساقي الاخري أثناء فصل الصيف. الأرز المحصول الأكثر تكاليف بينما القمح أقل التكاليف وتكلفة الري لفدان البرسيم في المسقي الترابية(الغير مطورة) كانت أعلي بحوالي ٣١ % من تكلفته في المساقي المطورة والمساقي المطورة أعطت أفضل تكلفة متوسطة لكل وحدة مساحة وبوجه عام النظام المطور حقق أقل التكاليف.
- وجد أن متوسط الكفاءة التطبيقية للري بالنسبة للمساقي المطورة كانت أعلي منها للمسقي الغير مطورة بالنسبة لجميع المحاصيل محل الدراسة.وبوجه عام قد لوحظ زيادة في الإنتاجية في المساقي المطورة عنها في المسقي الترابية في الموسم الشتوي بحوالي ٢٤,١٦ ، ٢٥,٢٢ و ٢٠,٠١ % لبنجر السكر ، القمح والبرسيم علي التوالي ، بينما في المحاصيل الصيفية كانت القيم المتزايدة ٣٠,٩٢ ، ٢٧,٥٥ و ٢٤,٤٥ % للأرز ، الذرة والقطن علي التوالي.

نظرا لأن قنوات الري المطورة أدت ألي توفير مياه الري وبالتالي تقلل من مشاكل الصرف وتحسن خواص التربة وترفع كفاءات استخدام المياه وتحقق عدالة توزيعها وذات تكلفة اقتصادية أقل وإنتاجية أعلي فالتطوير يرفع كفاءة نقل المياه أعلي من ٩٠% ، كفاءة التطبيق إلي ٨٠ % لتصبح كفاءة الري ٧٢ % لذلك نوصي باستخدام المسا قي المطورة وخاصة خطوط المواسير في منطقة الدلتا.

Table 6: Average conveyance efficiency (Ec) and water utilization efficiency (WUE) for selected crops at different meskas on Dakalt canal.

Treat.	Berseem		Wheat		Sugar beet		Rice		Cotton		Maize		Mean	
	Ec, %	WUE, kg/m^3	Ec, %	WUE, kg/m^3	Ec, %	WUE, kg/m^3	Ec %	WUE kg/m^3	Ec %	WUE kg/m^3	Ec %	WUE kg/m^3	Ec, %	WUE, kg/m^3
Meska1	96.4	1.49	95.7	1.55	95.5	8.25	96.9	0.63	0.0	0.0	0.0	0.0	96.13	1.99
Meska 2	96.2	1.41	96.0	1.42	95.4	8.56	96.5	0.61	94.5	0.44	95.0	1.08	95.60	2.25
Meska 3	95.2	1.64	95.6	1.54	95.6	8.49	96.2	0.62	94.0	0.39	94.5	1.07	95.18	2.29
Meska 4	92.6	1.39	92.2	1.66	91.7	7.45	95.4	0.59	91.3	0.40	92.2	1.05	92.57	2.09
Meska 5	92.9	1.36	91.9	1.78	92.3	7.28	94.2	0.59	91.9	0.36	93.7	0.98	92.82	2.06
Meska 6	94.5	1.51	95.6	1.79	95.3	8.28	95.7	0.65	94.7	0.43	94.1	0.88	94.98	2.26
Meska 7	79.6	0.98	83.1	1.10	87.1	4.92	86.2	0.42	85.2	0.22	86.2	0.70	84.57	1.39