IMPROVING IRRIGATION WATER CONVEYANCE AND DISTRIBUTION EFFICIENCY USING LINED CANALS AND BURIED PIPES UNDER EGYPTIAN CONDITION

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<u>ABSTRACT</u>

A field experiment was carried out at El-Mahmoudia command area at El-Beheira governorate, Egypt, during two growing seasons summer and winter 2014/2015, to Improve irrigation water conveyance efficiency using lined canal and upvc buried pipes under Egyptian conditions. The experiment consists of three types of on-field water distribution canals (Merwas); Earthen canal, Lined canal and Upvc buried pipes. Six Evaluation parameters were measured; conveyance efficiency, water saving, irrigation time, land saving, cropping intensity and crop yield, the financial analysis had been applied. The result showed that the conveyance efficiencies were 65%, 9٢.2% and 98.7% in winter, while the conveyance efficiencies were 59.6%, 87.1% and ٩٨.7% in summer, for earthen canal, lined canal and buried pipes, respectively. The impact of development on reducing conveyance losses comparing with earthen canal were 68.1% and 96.3 for summer, while it was 77.7% and 96.3 for winter, under lined canal and upvc buried pipes, respectively. The impact of improvement on decreasing irrigation time was ranged from 50% to 60% for the different field crops. The benefits of land saving were about 0.8% of the total saved area after development by lined canal and 1.4% of the total command area saved after development by upvc buried pipes, it had become available for agriculture. The highest profit as a percent was obtained under maize, for both lined canal and buried pipes, respectively.

Keywords: *Conveyance efficiency, earthen canal, lined canal, buried pipes.*

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1. INTRODUCTION

Egypt is characterized as arid climate with very limited rainfall. The vast majority of the country is desert land, and crop production is virtually fully dependent on irrigation. Egypt gets more than 95 % of its annual renewable water resources from the Nile. Egypt may face significant water scarcity within the foreseeable future, however, because of the combination of a more or less fixed supply of fresh water and increasing demands for water owing to population growth and reclamation of desert land for agricultural production. The major water user in the Egyptian economy agriculture is the largest user of water consuming 86.5% of the total water amount used, compared to 5.8% and 7.7% for municipal and industrial uses, respectively **FAO Aquastat, (2008)**.

Ibrahim, (2003). in the traditional irrigation system in the old lands, water is delivered to farmers on a rotational basis, which is normally applied at the branch canals. This system has some disadvantages such as; severe shortage of water at the tail reaches; low conveyance efficiency; high operational cost; and excessive water loss to drains. Tremendous efforts should be implemented towards effective management for irrigation system

Hvidt (1998), have shown that farmers have applied 50 % to 250 % more water than required by the crops and for the purpose of leaching.

According to **Ali (2011),** the conveyance efficiency in irrigation projects is poor due to seepage, percolation, cracking and damaging of the earth channel. Seepage losses in irrigation water conveyance system are very significant, as it forms the major portion of the water loss in the irrigation system the geometric factors involved in the estimation of the seepage are the shape and dimensions of the irrigation channel and the depth of the water table and the depth to an impervious layer. **Anonymous,(2014)**.the conveyance efficiency in the unlined irrigation system, which is about 56 %, can be increased to 88 %, when the whole system is lined. Therefore, there is considerable scope of improving the efficiency of water use by lining the system **Rahman *et al*. (2011),** revealed that average conveyance efficiency of UPVC buried pipe ranged from 94.46 % to 95.37 % and rate of water loss ranged from 5.45 % to 9.55 per cent. The

conveyance efficiency of pipe flow increased up to 95 % .**Arshad and Ahmad (2011),** lining has increased 25% conveyance efficiency and if we lined all other watercourses not only conveyance efficiency will be improved but will also help in equal water distribution among farmers and will increase the command area of that watercourse.**Sayed.,(2014).** found that **c**onveyance losses were to be 41%, 48% and 45% in existing earthen canals at Mithapukur, Manikganj Sadar and Dhamrai respectively. The reducing of canal losses would improve the efficiency of the irrigation systems and, consequently, it would reduce also the amount of water diverted for irrigation.

Akbar *et al.* (2013), said that reducing canal losses would improve the efficiency of the irrigation systems and, consequently, it would reduce also the amount of water diverted for irrigation. **Sahu *et al*., (2014)**. Some of the most important tangible benefits resulting from lining irrigation canals those that can be evaluated with some accuracy are water saving that would otherwise be lost though seepage, reclamation of water logged lands, lower maintenance and economies of canal lining operational cost. **Memon, *et al*., (2013)**. Lining provides flatter hydraulic gradient or bed slope, prevents silting of channels, makes bankers stable, acts anti-water logging measure as it reduces seepage to the adjoining land and it also reduces weed growth and increases stability of section. **Schwab *et al*., (1993)**.Pipeline delivery systems eliminate almost all the conveyance losses expected under open channel delivery systems. Low pressure buried pipe distribution systems for surface irrigation constitute evaluable alternative to open channel distributors. **Maniruzzaman et al. (2002),** reported that the conveyances loss was 2.8 to 9.5% in PVC and plastic pipe whereas in earthen channel it varied from 30 to 33% in silty-clay loam soil. **Kotb and Boissevain (2013),** conducted a field study and confirmed the figures of 2% land savings, conveyance efficiency of 98%, reduction in irrigation time of 50-60%, 5-30% increase in crop yields and added that overall water savings of 10% in summer and 5% in winter were achieved since the implementation of the Irrigation Improvement Project (IIP).

INCID, (1998). the advantages of low pressure buried pipe operation, maintenance and management of the off farm systems are easier and less

costly than that of surface distributors. Under the environmental perspective, advantages relate to reduced water losses, more efficient use of agricultural land, reduced damage of land through waterlogging and salinity, reduced damage of water resources, greater transit efficiency, control of aquatic weeds and associated pests. But the disadvantages are investment costs generally higher. **Javaid, et al. (2012),** said that lining is a long term effective technique for reducing seepage losses from watercourses but it is a highly cost intensive, in addition the lining improvement provides a smooth surface, the sagacity coefficient decreases as the resistance to flow decreases and hence velocity of flow increases. **El-Kassar, (2007).**Irrigation water is generally delivered below field level each farmer simply pumps irrigation water from the open mesas using a pump that the farmer either owns himself or hires when he wants to irrigate, and thus farmers incur pumping costs when irrigating but over time low-cost powered pumps have become available.The replacement of individual pumping units with a centrally operated pumping system, which managed by the users themselves through water user associations, improves irrigation efficiency. The shift from individual to collective pumping has reduced operational costs by one-third.

Therefore, the main objectives of this study were achieve a good irrigation management by increasing conveyance and distribution efficiencies, decrease water losses due to poor existing canals and decreasing operating energy by using upvc buried pipes.

2. MATERIALS AND METHODS

Evaluation was carried out at El-Mahmoudia command area, Kafr El-Dawar, El-Beheira Governorate Egypt. which Located in the northern part of the country in the Nile delta its coordinates 30.61°N, 30.43°E, El-Mahmoudia canal off-takes from Rosetta branch at 194.2km .

2.1. Experimental locations

2.1.1. Abdel-Mawgoud station The station located on left band for Abees El-gadeda branch canal, which service 73fed. the Measurements were carried out to 3 Merwas UPVC buried pipe 4 bar operating pressure,

250 mm diameter and water point $6^{\backslash\backslash}$/fed a description of Abd EI-Mawgoud pumping station and measuring points are shown in Table (1) and (2).

2.1.2. Om El-laben station the station located at om El-Laban station El-Mesqa El-Baharia on the right band for El-Qenawya branch canal which service 149 fed and 8 carats, the Measurements were carried out at 3 rectangular open concrete-lined canal dimensions of bases (90cm width x 8cm thickness), sides from red blocks (40cm height, Cover the sides in and out by cement and sand the canal dimensions (40 x 40 x 40cm) (Table 3 and 4).

2.1.3. Bloktor district located on the right band for small branch canal Gnnabyt Zohra (2 km length and 700 fed served area). Off-takes from El-Mahmoudia main canal the measurements points on 3 unlined Merwas which take the water from branch canal directly by the private farmer's pumps table (5) description of 3 Merwas

2.2. Evaluating parameters
2.2.1. Determination of conveyance efficiency Water conveyance efficiency (E_C) is the ratio in percent of the amount of water delivered by a channel or pipeline to the amount of water delivered to the conveyance system. Conveyance efficiency (E_C) was computed with the adoption of the following formula **(James, 1988):**

$$E_C = (Q_o / Q_i) *100 \tag{1}$$

Where:
E_C: conveyance efficiency in percent,

Q_o: quantity of water delivered by a conveyance system (outflow)

Q_i: quantity of water delivered to a conveyance system (inflow)

2.2.1.1. Unlined open canal
There are several methods of measuring flow in open irrigation channels on the farm. The velocity-area method was adopted to measure the rate of

flow in three earthen canals. The rate of flow passing a point in an open channel was measured by multiplying the cross-sectional area of the flow section at right angles to the direction of flow by the average velocity of water.

Q = A * V   (2)

Where,

Q = discharge rate (m^3/s)

A = area of cross-section of canal (m²)

V = average velocity of flow (m/s)

The cross-sectional area was determined by direct measurements. The velocity was measured by float method. A straight section of channel about 30 m long with fairly uniform cross-section was selected. Several measurements of depth and width were made within the trial section to arrive at the average cross sectional area. To determine the velocity of surface water of the channel, the length of trail section was divided by the average time taken by the float to go through the 30m section. Since the velocity of the float on the surface of the water will be greater than the average velocity of the stream, it was necessary to correct the measurement by multiplying by a constant factor (velocity correction factor) which is usually assumed to be 0.66 according to **(James, 1988).** To obtain the rate of flow, this average velocity (measured velocity * correction factor) was multiplied by the average cross-sectional area of the stream.

Table 5. The description of measurements points on 3 Merwas.

Merwa type	Serviced area (fed)	Merwa length (m)
unlined	4	200
unlined	6	250
unlined	6	350

Table 1. Description of the Abees pumping station.

Pump Type	Power source	Pump head (m)	r.p.m	Motor horse power (HP)	Q (m³h⁻¹)	Number of pumps	Installation date
Centrifugal	Electricity	13	1470	10	110	3	2012

Table 2. The description of measurements points on 3 Merwas.

No. of Merwas	No. of outlets	No. of valves	Serviced area (fed)	Outlet	Outlet diameter (mm)	Marwa length (m)	Merwa pipe type	Distance from pumping station (m)
1	12	1	8	Hydrant	160	250	UP.V.C.	20
2	9	16	6	Hydrant	160	241	UP.V.C.	778
3	4	9	4.5	Hydrant	160	148	UP.V.C.	1011

Table 3. Description of the Om El-Laben pumping station.

Installation date	Power source		Pump head (m)		Q (m³h⁻¹)		No. of pumps	Pump Type
	Elec.	diesel	Elec.	diesel	Elec.	diesel		
2004	2	1	11	10	220	220	3	Centrifugal

Table 4. The description of measurements points on 3 Merwas.

Marwa number	No. of outlets	Outlet Type	Serviced area (fed)	Merwa length (m)	Space from pumping station (m)	Merwa type
1	9	Gate 40 cm	9	821	70	lined
2	3	Gate 40 cm	4	200	150	lined
3	15	Gate 40 cm	15	772	270	lined

2.2.1.2. Lined open canal

A rectangular weir was used to measure the rate of flow of lined open canal, where the sides of the weir are actually the sides of the channel, it is called a suppressed rectangular weir. The rate of flow passing a point in lined open canal was estimated by applying the following formula:

$$Q = 0.0184.L. H^{3/2} \tag{3}$$

Where;

Q: The discharge over the Weir (l/s)

L: The length of weir (cm)

H: The high of water on the weir (cm)

2.2.1.3. Buried pipe

The discharge from buried pipe was measured using Trajectory method. In this method the rate of flow is obtained by coordinate determination of any point of flow under operating condition, the flow at the outlet of pipe should be full. pipe may be horizontal or vertically just above the jet. In this flowing condition the pipes were vertically. The inside diameter "D" of the pipe was measured. Based on experimental work, **Bos (1989)**, present to the following semi-empirical relationship:

$$q = 3.48. \, d^2. \, \Delta h^{0.5} \qquad \text{most accurate for } \Delta h > 1.4d \tag{4}$$

Where:

q: discharge (m^3/s)

d: inside diameter (m)

h: head of water (m)
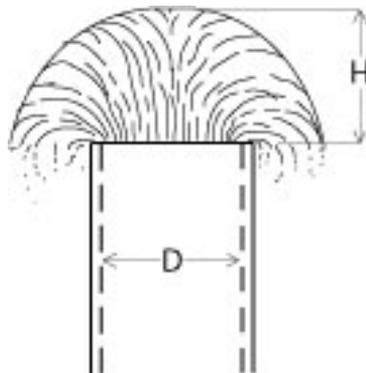
Fig. 1. Trajectory vertically method

2.2.2. Determination of water losses

The conveyance loss was measured using the inflow-outflow method, which involves measurement the rate of water flows at water course test section and the rate of water flows out of it. estimation of Conveyance losses is essential to make decisions while designing an irrigation channel or allocating water supplies at the head of canal. Inflow-Outflow method has been used as bench mark method **Sarki *et al*.,(2008).** In this method, actual discharges are measured between two selected points on canals. in order to estimate water losses and conveyance efficiency in unlined canal, lined canal and buried pipe. in three water distribution, earthen channel volume of water (inflow and outflow) was measured by the velocity-area method in lined channel. Two rectangular weirs were installed at sections A, B Thus the difference of discharges at section A and B gave conveyance losses in the lined canal. The Conveyance losses were estimated by following formula:

$$CL = \frac{(Q_{in} - Q_{out})}{Q_{in}} \times 100 \tag{5}$$

Where:

C_L = Conveyance losses (%)

Q_{in} = Inflow rate (m^3/h)

Q_{out} = Out flow rate (m^3/h)

2.2.3. Financial analysis The Financial analysis includes crop yield, cost of pumping, annual costs and benefits and the cost of structures. The data about crop yield, cost of pumping, annual costs and benefits from the field survey were carried out through questionnaire from the farmers in the experimental area. The data recorded on recall basis comprise of the area under main crops by each farmer before and after the development of canals for the crop season 2014-2015. The data was collected by interviewing the landowners located on the head, middle and tail reach of sample watercourse according to the plan made for the comparison of the events reach wise before and after development, the interviews were conducted with all types of land owners from small to large area.

2.2.3.1. Pumping cost The cost of pumping per year for Abdel-Mawgoud station before development includes different items such as cost of fuel and oil, maintenance and clean Merwa. After improvement, the pumping

cost includes salary of the pump operator and guard, cost of energy, maintenance and clean of Merwa. The cost of pumping wear calculated as shown in table (6) and (7).

2.2.3.2. The cost of structures The costs of lining for the life of lined potion of water courses have been collected from on farm irrigation development projects management unit - ministry of agriculture and land reclamation. The capital costs of structures for the Merwa which has 250m length In the lined canal the cost of structures for the Merwa was identifying 119 L.E/m length, this includes cleaning the ground from the previous crop, concrete bases (length of Merwa – width 90cm - thickness 8cm), Sides from red blocks 40 Cm height, Cover the sides by cement and sand. the canal dimensions (40cm x 40cm x 40cm). and 115 L.E for iron gate 40cm × 40cm that one gate per fed and in upvc buried pipes. cost of structures was identifying 50 L.E/ m this include pipes 250mm diameter, digging, recover the pipe, installation pips and pipes test in the field and 700 L.E for iron hydrant 6" riser 1m P.V.C. pipe, 160mm out diameter, concrete block and concrete cylinder or cover the hydrant, each 4200m^2 has one hydrant

2.2.3.3. Annual costs and income

The main costs, benefit and the net income earned from the irrigated area before and after development it includes the overall cost of production (L.E./fed) and overall net income received (L.E./fed). Thus, total annual profits were estimated Effect of development by lined canal or buried pipes on farmers' income.

2.4. Statistical analysis

An analysis of variance (ANOVA) was performed by considering the variables related with water distribution systems (earthen canals, lined canals and upvc buried pipes) and the variables related with wheat ,alfalfa, maize and rice yield to estimate the effect of irrigation conveyance systems development on water Conveyance efficiency (E_C), Conveyance losses(C_L), irrigation time, water saving , land saving ,crop yield, cropping intensity ,cost of pumping, using M-Stat, Statistical Graphics Corp. Fisher's least significant difference (LSD) test was used to determine the significant differences between average groups in the ANOVA

Table 6. The pumping cost before improvement.

Agric. season	Field area (fed)	number of pumps	No. of irrigation	Fuel consumption cost (LE)	Oil consumption cost (L.E)	Clean Merwa (L.E)	Maintenance (L.E)
winter	73	14	40	15768	1428	925	2800
summer	73	14	86	33901	2856	925	2800

Table 7. The pumping cost after improvement

Agric. season	Field area (fed)	Number of pumps	No. of irrigation	Electricity Cost (L.E)	Maintenance (L.E)	Cleaning of Merwa (L.E)	Guarding and operation (L.E)
winter	73	3	40	3000	150	925	6000
summer	73	3	86	4000	200	925	6000

.3. RESULTS AND DISCUSSIONS

3.1. Conveyance efficiency (E_C)

The conveyance efficiencies under earthen canals were 59.6% and 65.1% in summer and winter seasons, respectively, while the conveyance efficiency was raised after improvement under lined canals and upvc buried pipes, respectively. The conveyance efficiencies under upvc buried pipes were higher than of those achieved under lined canals. The results reveal that the less conveyance efficiency in earthen canal was due to lack of proper maintenance of the earthen canal hence more seepage and leakage losses due to the presence of vegetation. There were a significantly differences between conveyance efficiencies under different types of Merwa, while there weren't a significantly differences between the both growing seasons for each Merwa type (Table 8).

Table 8. The conveyance efficiency of the three types of Merwa.

Type of Merwa	Conveyance efficiency (%)	
	Summer	Winter
Earthen canal	59.6 c	65.1 c
Lined canal	87.1 b	92.2 b
Buried pipe	98.7 a	98.7 a
LSD	5.457	

Means followed by the different letter are significantly different from one another based on Duncan's protected LSD test at $P \leq 0.05$.

These results were agreement with **Anonymous, (2014)** ,**Rahman *et al*. (2011),** and**Arshad and Ahmad (2011).**

3.2. Conveyance losses(C_L) the average Conveyance losses was measured by inflow-outflow method in earthen canal, was 40.5% in summer season and 35.2 % in winter season after development. The average Conveyance losses was 12.9 %, 1.3 % in summer season and 7.8 %, 1.3 % in winter season in lined canal and buried pipe respectively. Whereas there were higher in the earthen canal in both seasons it was due to lack of proper maintenance of the earthen canal hence more seepage, evaporation and leakage losses presence of vegetation.

The conveyance losses were lower in the lined canal in both seasons than earthen canal This was due to irregular shapes throughout the length and poor maintenance of the field channels and they haven't lost their regular shapes after construction. buried pipe achieved the lowest conveyance losses in the both seasons and highest percentage of reduction in the annual losses it was 96.3% to 96.8 % compared with 68.1% to 77.7 % of reduction (Table 9).

There were a significantly differences between conveyance losses under different types of Merwas, while there weren't a significantly differences between the both growing seasons for each Merwa type.

The result is in conformity with the findings of **Rahman *et al*., (2011). and Maniruzzaman et al. (2002),**

3.3. Water saving

Improved canals were intended to eliminate the losses of water through their cross sections. Improvement the irrigation conveyance system in command area contributed to save some quantities of water The amounts of water that are lost from the earthen canal which were 35% to 40.4% and 27.2% to 27.5% are saved after the development by lined canal that saved due to reduction seepage and leakage losses presence of vegetation. The highest amount of saved water was achieved after development by upvc buried pipes it was 33.7 % to 39.1 % that due to additional reasons of reduction losses in lined canal was prevented all amount of water which lost by evaporation to use them positively in the present days and in the future. There were a significantly differences in water saving after development by lined canal and upvc buried pipes, while there weren't a significantly differences between the both growing seasons for each Merwa type (Table 9).

3.4. Irrigation time
the irrigation time for field crops in command area before development in winter season was ranged from 4 to 5 h/fed, while in summer season it was 5 h/fed. After development, the irrigation time decreases to 2 h/fed in winter season, while it decreases to 2.5 h/fed in summer season (Fig. 3). The impact of improvement on decreasing irrigation time was ranged from 50% to 60% for the different field crops.

Table 9. The conveyance losses and water saving.

Type of Merwa	Conveyance losses (%)		Water saving (%)		Development impact on reducing conveyance losses (%)	
	Summer	Winter	Summer	Winter	Summer	Winter
Earthen canal	40.4 a	35.0 a	-	-	-	-
Lined canal	12.9 b	7.8 b	27.5b	27.2b	68.1	77.7
Buried pipe	1.3 c	1.3 c	39.1a	33.7a	96.8	96.3
LSD	5.457		5.476			

Means followed by different letters for conveyance losses are significantly different from one another based on Duncan's protected LSD test at P ≤ 0.05.and the Means followed by different letters for saved water are significantly different from one another based on Duncan's protected LSD test at P ≤ 0.05.
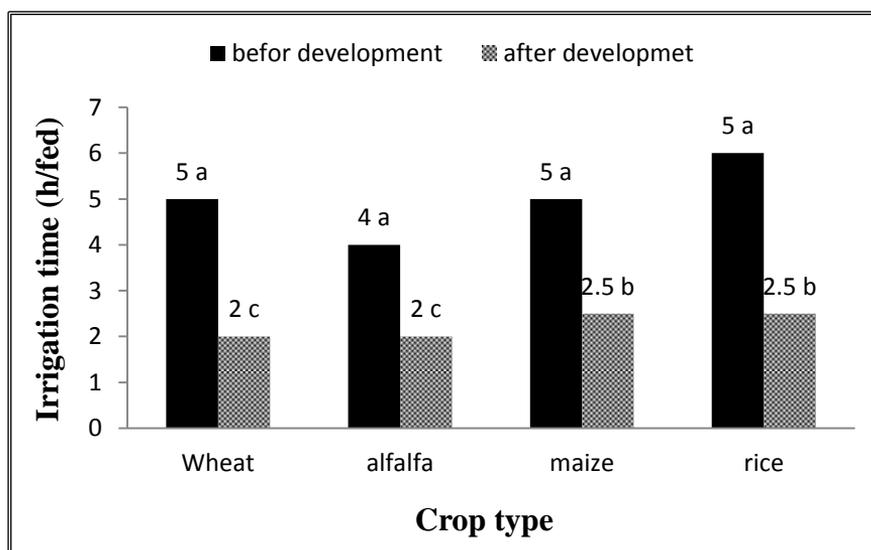
Bars shown with different letters are significantly different at the 0.05 probability level for irrigation time and crop type and least significant difference (LSD) for irrigation time under different crop types equals 0.1883.

Fig. 3. Impact of improvement on decreasing irrigation time.

This decrement of irrigation time is due to irregular irrigation time among the farmers in improved Merwas and single lifting point. Improvement process made water available all the time in the Mesqa, better scheduling

of irrigation and higher flow rate at the field level has also contributed to reduce the irrigation time.

There were a significantly differences for irrigation time after development of Merwa and there were a significantly differences between the both growing seasons for upvc buried pipes ad lined canal (Fig. 3). These results were agreement with **Kotb and Boissevain (2013).**

3.5. The impact of development on agricultural area

There was a positive influence of development on agricultural area, where there was an increment of agricultural area by 34 m^2/fed and 59 m^2/fed under lined canal and upvc buried pipes, respectively. It may be noted that with the rise in the agricultural area there has been a concomitant increase in the crop yields of the land saving or land increase; which is a result of the construction of improved Merwas as compared to areas occupied by old Merwas. These benefits of land saving were about 0.8% of the total saved area after development by lined canal and 1.4% of the total command area saved after development by upvc buried pipes, it had become available for agriculture and roads (Table 10).

Table 10. The effect of development on command area

Type of Merwa	Agricultural area (m^2/fed)		Total saved area (m^2/fed)	Total saved area (%)
	Before development	After development		
Lind canal	4109	4143	34	0.8
Buried pipes	4141	4200	59	1.4

3.6. Cropping intensity

It is evident that annual cropping intensity before and after improvement were 195.66% and 197.28% under lined canal, respectively, while the cropping intensity before and before development under buried pips were 197.20% and 200%, respectively. There was a positive impact of improvement on cropping intensity, where there was an increment of cropping intensity by 1.6% and 2.8% under lined canal and upvc buried pipes, respectively (Table 11).

Table 11. The impact of development on cropping intensity.

Type of Merwa	Cropping intensity (%)						Increment (%)
	Winter		Summer		Annual		
	Before	After	Before	After	Before	After	
Lined canal	97.83	98.64	97.83	98.64	195.66	197.28	1.6
Buried pipes	98.60	100	98.60	100	197.20	200	2.8

3.7. Crop yield

The improvement process has an agricultural benefit like increment in crop yields due to the better conditions of water availability. Wheat had the lowest increment of crop yield among field crops by 16 to 30 kg/fed under wheat for lined canal and upvc buried pipes, respectively, while the Alfalfa had the largest increment in crop yield by 290 to 510 kg/fed, for lined canal and upvc buried pipes, respectively. The yield increment as a percentage for all field crops were 0.8% and 1.4% for lined canal and upvc buried pipes, respectively (Table 12).

There were a non-significantly differences for crop yield between lined canal and upvc buried pipes, but there were a significantly differences between the both growing seasons for upvc buried pipes ad lined canal

Table 12. Impact of development on crop yield.

Crop type	Yield increment (Kg)		Yield increment (%)	
	Lined canal	Buried pipes	Lined canal	Buried pipes
Wheat	16 a	30 a	0.8	1.4
Alfalfa	290 a	510 a	0.8	1.4
Maize	21 b	37 b	0.8	1.4
Rice	28.3 b	49.2 b	0.8	1.4
LSD	340.9	730.2		

3.8. Financial analysis

3.8.1. Pumping cost

The cost of pumping for Abdel-Mawgoud station before development was 554 L.E in summer season and 287L.E in winter season, after improvement the pumping cost was decreasing to be 138L.E in winter and 153L.E in summer (Fig. 4). Lower pumping costs due to a decrease

or absence of many of the items used to calculate the pumping costs, such as; the absence of fuel and oil costs that used to run the diesel pumps to be replaced by electrical pumps, reduce the number of pumps used from 14 diesel pumps with multi lifting points to 3 electrical pumps with a single lifting point, get rid of the high maintenance costs of pumps that operate by diesel as well as special clean specular weeds and sludge accumulated maintenance costs at the bottom of irrigated canals and that has helped farmers in best scheduling of irrigation water, which reflected in turn, reduce production costs and increase profits.
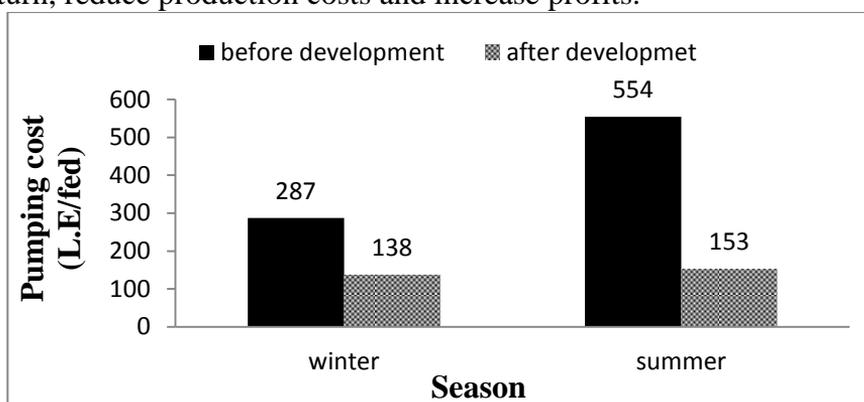

Fig. 4. The pumping cost in growing seasons.

3.8.2. Cost of structures

The cost of structures for improvement by lining was high and need to be reduced. The costs of construction of the open elevated and upvc buried pipes were 3833.75 L.E./fed and 2887.5 L.E./fed, respectively, it was cleared that the cost of structures for upvc buried pipes less than lined canal by about 950 L.E./fed (Table 13). The result is in conformity with **Javaid, et al. (2012**

Table 13. The cost of structures for Merwas.

Merwa type	Merwa length (m)	Serviced area (fed)	Cost of Structure (L.E./m)	Offtake type	Offtake cost (L.E.)	Total cost (L.E.)	Cost (L.E./fed)
Lined canal	250	8	119	Gate	115	30670	3833.75
Buried pipe	250	8	70	hydrant	700	23100	2887.5

3.8.3. Annual costs and income

As discussed before the yield increment as a percentage for all field crops were 0.8% and 1.4% for lined canal and buried pipes, respectively (Table 14 and 15). The highest profit as a percent was obtained under maize, for both lined canal and buried pipes, respectively, while the lowest profit was recorded under wheat for both lined canal and buried pipes, respectively.

Table 14. Effect of development by lined canal on farmers' income.

Crop type	Evaluation parameters	Earthen canal	Lined canal	impact	Percentage (%)
Wheat	Cultivated area (m^2)	4109	4143	+ 34	0.8
	Yield (Kg)	2132	2148	+ 16	0.8
	Product cost (L.E.)	2910	2735	- 175	6.0
	Income (L.E.)	5880	5920	+ 40	0.7
	Profit (L.E.)	2970	3185	+ 215	7.2
Alfalfa	Cultivated area (m^2)	4109	4143	+ 34	0.8
	Yield (Kg)	29744	29984	+ 240	0.8
	Product cost (L.E.)	1980	1755	- 225	11.4
	Income (L.E.)	3161	3186	+ 25	0.8
	Profit (L.E.)	1181	1431	+ 250	21.2
Maize	Cultivated area (m^2)	4109	4143	+ 34	0.8
	Yield (Kg)	2603	2624	+ 21	0.8
	Product cost (L.E.)	2800	2575	- 225	8.0
	Income (L.E.)	3718	3748	+ 30	0.8
	Profit (L.E.)	918	1173	+ 255	27.8
Rice	Cultivated area (m^2)	4109	4143	+ 34	0.8
	Yield (Kg)	3424.2	3452.5	+ 28.3	0.8
	Product cost (L.E.)	4100	3775	- 325	7.9
	Income (L.E.)	6120	6210	+ 90	1.5
	Profit (L.E.)	2020	2435	+ 415	20.5

Finally, all the results presented before indicated that improving conveyance efficiency by using buried pipes gave highest values for cultivated area for all crops and highly net profit, in addition this means that buried pipes will be the key for successful irrigation management.

Table 15. Effect of development by buried pipes on farmers' income.

Crop type	Evaluation parameters	Earthen canal	Buried pipes	impact	Percentage (%)
Wheat	Cultivated area (m^2)	4141	4200	+ 59	1.4
	Yield (Kg)	2145	2175	+ 30	1.4
	Product cost (L.E.)	2910	2715	- 195	6.7
	Income (L.E.)	5916	6000	+ 84	1.4
	Profit (L.E.)	3006	3285	+ 279	9.3
Alfalfa	Cultivated area (m^2)	4141	4200	+ 59	1.4
	Yield (Kg)	29968	30400	+ 432	1.4
	Product cost (L.E.)	1980	1730	- 250	12.6
	Income (L.E.)	3185	3230	+ 45	1.4
	Profit (L.E.)	1205	1500	+ 295	24.5
Maize	Cultivated area (m^2)	4141	4200	+ 59	1.4
	Yield (Kg)	2623	2660	+ 37	1.4
	Product cost (L.E.)	2800	2550	- 250	8.9
	Income (L.E.)	3746	3800	+ 54	1.4
	Profit (L.E.)	946	1250	+ 304	32.1
Rice	Cultivated area (m^2)	4141	4200	+ 59	1.4
	Yield (Kg)	3450.8	3500	+ 49.2	1.4
	Product cost (L.E.)	4100	3750	- 350	8.5
	Income (L.E.)	6228	6300	+ 72	1.2
	Profit (L.E.)	2128	2550	+ 422	19.8

4.CONCLUSIONS

The main conclusions of this research can be proposed as follows:

- ✓ The increasing of the inflow discharge to the area under study can be achieved through optimizing use of the available quantities of Nile water belongs to the study area, at the same time, the increasing of the inflow discharge to the study area can be achieved through minimizing the losses of water by seepage, percolation and evaporation.
- ✓ The results presented before indicated that improving conveyance efficiency by using upvc buried pipes gave highest values for cultivated area for all crops, in addition this means that upvc buried pipes will be the key for successful irrigation management under Egyptian conditions.
- ✓ Fairness of water distribution along Mesqas improved to about 97%.
- ✓ Land saving: There is about 1 % of the total command area has been saved and made available for agriculture and roads.
- ✓ The use of upvc buried pipes has a special clean specular weeds and sludge accumulated maintenance costs at the bottom of irrigated canals and that has helped farmers in best scheduling of irrigation water, which reflected in turn, reduce production costs and increase profits.
- ✓ The applying of single lifting point and electrical pumps will achieve many advantages including; decreasing pumping costs, reducing the number of pumps used from 14 diesel pumps to 3 electrical pumps, get rid of the high maintenance costs of pumps that operate by diesel.

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الملخص العربي

تحسين كفاءة نقل وتوزيع مياه الري باستخدام القنوات المبطنة والأنابيب المدفونة تحت الظروف المصرية

إسماعيل عبده محمدعثمان* ، جمعة عبدربه بكير** ، محمد السيد ابوعرب*** و مجدي توفيق الطنطاوي****

اجريت التجربة في منطقة المحمودية ،كفر الدوار ، محافظة البحيرة ، مصر خلال موسمي الصيف والشتاء ٢٠١٤ـ ٢٠١٥ لتحسين كفاءة نقل وتوزيع مياه الري باستخدام القنوات المبطنة والانابيب المدفونة تحت الظروف المصرية وقد استخدم ٦ عوامل للتقييم وهي كفاءة النقل ، توفير المياه ، زمن الري ، توفير الارض ،والكثافة المحصولية ، انتاجية المحاصيل ، والتحليل المالي وقد اظهرت النتائج ان كفاءة النقل كانت ٦٥% ، ٩٢.٢ % و ٩٨.٧% في موسم الصيف و ٥٩.٦ % ، ٨٧.١ % و ٩٨.٧ % في موسم الشتاء للقنوات الترابية ، والقنوات المبطنة والانابيب المدفونة علي الترتيب ، وتاثير التطوير علي نسبة التقليل في فواقد النقل بالمقارنة بالقنوات الترابية كانت ٦٨.١ %و ٩٦.٣ % في موسم الصيف و ٧٧.٧ % و ٩٦.٣ % في موسم الشتاء للقنوات المبطنة والانابيب المدفونة علي الترتيب ، تاثير التحسين علي تقليل زمن الري كان يتراوح مابين ٥٠ % الي ٦٠ % لمختلف المحاصيل الحقلية وكانت نسبة التوفير في مساحة الارض حوالي ٠.٨ % مع القنوات المبطنة و ١.٤ % بعد التطوير بالانابيب المدفونة واصبحت الارض الموفرة متاحة للزراعة او للطرق . وتحقق اعلي ربح في محصول الذرة بعد التطوير بالقنوات المبطنة والانابيب المدفونة علي الترتيب .
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