Tanta University
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STUDY ON DEVELOPING OF IRRIGATION METHOD IN DELTA REGION

By

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Approval Sheet

"Study on Developing of Irrigation Method in Delta Region"

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2005

بسم الله الرحمن الرحيم

قالوا سبحانك لا علم لنا إلا ما علمتنا إنك أنت العليم الحكيم

صدق الله العظيم

البقرة آية ٣٢

Abstract

STUDY ON DEVELOPING OF IRRIGATION METHOD IN DELTA REGION

By

AZZA ABD EL-SLAM MOHAMED EL-HENDAYE

The present work was carried out at El-Karada station, " Kafr El-Sheikh Governorate during Summer season of 2003.

The parameters for different treatments were calculated as follows :-

1-Amount of applied water to each treatment	4-Corn yield
2-Root volume.	5- Water use efficiency
3-Leaf area index.	6-Conveyance effieciency

According to the obtained results , it concluded that .

1-Applied irrigation water

The lest amount of water was 2331m^3 by used cannal lining irrigation at 13 m furrow length and 2m^3 / min discharge but highest amount applied water was 3062 m^3 by used unlining canal at 40 m furrow length and 1m^3 / min discharge . Cannal lining saved water by 19 % compared with un lining .

2- Root volume:-

The highest volum was 734 cm ^{3} by used canal lining at 40m furrow length and 1m^3 / min but least volum was 320 cm ^{3} by using unlining canal at 27 m and 1m^3 / min discharge .

3-Leaf area index:- the highest value was 3.67 by using canal lining at 40 m furrow Length and 2m^3 / min discharge but least value was 1.9 by using unlining canal at 13 m furrow length and 1m^3 / min discharge

4-corn yield :

The hightest yield 3867 kg / fed by used cannal lining at 40m furrow length and 2m^3 / min discharga but least yield 2973 kg / fed at 13 m furrow length and 1m^3 / min by used unlining cannal

5-Water use efficiency : -

The highest value was 1.58 by using canal lining at 13m furrow length and 2m^3 / min discharge but least value was 1.03 by using unlining canal at 40 m furrow length and 1m^3 / min discharge

6-Conveyance effieciency:-

Conveyace effieciency for lining canal was 95% aproxmatly but 82 % for unlining canal .

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1. INTRODUCTION

Water is the source of life. As a matter of fact it includes all life with its aspects in recent times, the world is threatened by shortage of water and agriculture itself consumes the highest rate of water. This serious case attracters the attention of scientists and makes them to do their bests for solving this problem. Therefore, shortage of mater becomes one of the principle elements of poverty and starvation in the world.

Irrigation was initially introduced in Egypt as surfaced irrigation, since more 6000 B.C. ***(Nakayama and Bucks, 1986)***. Surface irrigation is practiced as flooding the soil surface with water and the losses of water was increased. Therefore, effective water management is considered as a main national target. Effective water management means the determination of the exact amount of water should be delivered to the growing crop at convenient time with the most proper irrigation method.

In Egypt, the problem of water deficit becomes more serious, especially, with 72th high population and fixed amount of Nile water which considered as the source of irrigation water. So that, water management, will play an important role on improving the surface irrigation, furrow practices.

Mentioned that furrow irrigation is suitable for many crops, especially row crops. Crops that would be damaged if water covered their stem or crown should be irrigated by furrows. Furrows can be used on most soil types. However, as with all surface irrigation methods, very coarse sands are not recommended as percolation losses can be high. Soils that crust easily are especially suited to furrow irrigation because the water does not flow over the ridge and so the soil in which the plants grow remains friable ***(Brouwer et al., 1985).***

The objectives of the present work may be summarized as follows :

The objective of the present work to evaluate the irrigation conveyance under different condition(filed condition) inorder to save irrigation water, increase water distribution and maxumize water use efficiency .

2. REVIEW OF LITERATURE

2.1. Water management:

Fok and Bishop (1969) mentioned that water use of surface irrigation constitutes more than three-fourths of the consumptive use of water in arid or semiarid zones. If irrigation efficiency increases only ten percent, a huge amount of water will be saved for other uses. In order to increase the efficiency of surface irrigation, one has to under stand the relationship of the irrigation efficiency to the physical properties of the field to be irrigated.

Thomas and Clyma (1981)stated that there is potential for improvement in on-farm water management in the area, particularly in aiding farmers in determining the correct amount of water to apply, using the application and then determining when to irrigate. Perhaps the greatest aid can be accomplished by offering design recommendations to farmers on the ranges of furrow inflow rates and set times they should be using. Irrigation advisory services through extension or by irrigation scheduling can effectively improve timing and amounts of water applied.

Kamper et al. (1982) indicated that data in dicate that infiltration rates can generally be reduced by compaction to the levels desired. To some extent, farmers are already reducing intake rates and surface roughness of tractor wheel rows, etc. however, there appears to be a major potential for improving the engineering of irrigation systems if water intake by the soil can be changed to what is needed. Management of intake rates will require equipment and guidelines to achieve the desired compaction and means of measuring the resulting rates of intake.

Brouwer et al. (1985) mentioned that furrow irrigation is suitable for many crops, especially row crops. Crops that would be damaged if water covered their stem or crown should be irrigated by furrows. Furrows can be used on most soil types. However, as with all surface irrigation methods very coarse sands are not recommended as percolation losses can be high. Soils that crust easily are especially suited to furrow irrigation because the water does not flow over the ridge and so the soil in which the plants grow remains friable.

They added that the shape length and spacing are determined by the natural circumstances, i.e. slope, soil type and available stream size. However, other factors may influence the design of a furrow system such as the irrigation depth, farming practice and the field length.

Teferi Tsegaye et al. (1993) water extraction, depletion and sufficiency of wide-spaced furrow irrigation (WSFI) are well understood. In addition, there is little work showing the response of WSFI where the same seasonal amount of water was applied to both WSFI and every-furrow irrigation (EFI). Treatments in this study included two seasonal amounts of water applied to both the WSFI and (EFI) plots. We determined the yield of grain sorghum (*Sorghum bicolor* (L) Moench), water uptake (surface evaporation, extraction, and seasonal depletion), water penetration depth, and water use efficiency (WUE) during a 2-yr study in the Oklahoma Panhandle. A given amount of water produced about a 10% higher yield of grain sorghum when applied as WSFI than for EFI. The WUE of plants was found to be 24% higher for WSFI than for EFI. Evaporation from the soil surface was 30 mm greater for EFI than WSFI. The EFI resulted in 30 mm more water extraction from the soil, evidently to meet the demand of surface evaporation. Seasonal depletion was related to wetness of the treatment; depletion was 20 mm higher for the drier of the treatments. Following any periods where water was not available, WUE showed less water penetration depth than EFI. The WSFI appears to have benefit for irrigation of this crop.

Tabuada et al. (1995) toted that ahydrody manic furrow irrigation model (TRISUL) can give information on the paasition of the wetting front in the soil through time, allowing the quantification of the water stored in the root zone. It is therefore possible to choose the best inflow discharge, spacing between furrows and furrow shape to obtain the best irrigation efficiency.

Abu-Zeid and Hamdy (1996) mentioned that, some countries suffering from, or potentially suffering from, water shortage in the near future, have started to implement water savings programmes. These include reducing the current uses and the associated water losses and as developing other non-conventional water resources uses. In the process of implementing them, new technologies and trends are being practised such as:- lining of canals, on-farm irrigation improvement, artificial recharge to groundwater, annual water storage, use of new irrigation methods, reuse of agricultural drainage water, reuse of different levels of treated municipal and industrial waste water, use of fossil groundwater, desalination of sea water, and others.

Alazba (1999) Simulation of sloping furrows with free outflow was accomplished to assess the effect of inflow pattern on maximum application efficiency. For five inflow hydrograh patterns, the maximum application efficiency was predicted utilizing a zero inertia model, which describes the movement of water in the furrow with infiltration. The irrigation parameters considered were four infiltration families, three slopes, three roughness coefficients, two field lengths, three volumes, and one furrow shape and one furrow shape and size. The maximum application efficiencies averaged over all combinations for the five inflow patterns were constant rate, 58%; cutback, 64%; cablegation, 51%; modified cutback, 64%; and modified cablegation, 62%. Efficiencies ranged from zero for each inflow shape to a magnitude that differs from one to anther, with the low values occurring for high infiltration rates and roughness, small slopes, long fields, and low volumes of application. While the constant rate was least sensitive to changes in the input parameters, cutback and modified cutback were most sensitive. Cablegation and modified cablegation were moderately sensitive to changes in the input parameters.

Kang et al. (2000) designed and tested a new irrigation method for maize production for yield and water use efficiency (WUE). A field experiment was conducted in an arid area in gansu, China, with seasonal rainfall of 80 mm, over 2 years (1997 and 1998). Irrigation was applied through furrows in three ways: alternate furrow irrigation (AFI), fixed furrow irrigation (FFI), and conventional furrow irrigation (CFI). AFI means that one of the two neighbouring furrows was alternately irrigated during consecutive watering. FFI means that irrigation was fixed to one of the two neighbouring furrows. CFI was the conventional way where every furrow was irrigated during each watering. Each irrigation method was further divided into three sub-treatments with different irrigation amounts: 45, 30 and 22.5 mm water at each application. Results showed that root development was significantly enhanced by AFI treatment. Primary root numbers, total root dry weight, and root density were all higher in AFI than in FFI and CFI treatments. Less irrigation significantly reduced the total root dry weight and plant height in both FFI and CFI treatments but not as substantially with AFI treatments. The most surprising result was that AFI maintained high grain yield with up to 50% reduction in irrigation amount, while FFI and CFI all showed a substantial decrease in yield with reduced irrigation. As a result, WUE for irrigated water was substantially increased. AFI is a way to save water in arid areas where maize production relies heavily on repeated irrigation.

Kang et al. (2000) tested soil water distribution, irrigation water advance and uniformity, yield production and water-use efficiency (WUE) with a new irrigation method for irrigated maize in an arid area with seasonal rainfall of 77.5-88.0 mm for 2 years in China (1997 and 1998). Irrigation was applied through furrows in three ways: alternate furrow irrigation (AFI), fixed furrow irrigation (FFI) and conventional furrow irrigation (CFI). AFI means that one of the two neighbouring furrows was alternately irrigated during consecutive watering. FFI means that irrigation was fixed to one of the two neighbouring furrows. CFI was the conventional method where every furrow was irrigated during each watering. Each irrigation method was further divided into three treatments using different irrigation amounts: i.e. 45, 30, and 22.5 mm water for each watering. Results showed that the soil water contents in the two neighbouring furrows of AFI remained different until the next irrigation with a higher water content in the previously irrigated furrow. Infiltration in CFI was deeper than that in AFI and FFI. The time of water advance did not differ between AFI, FFI and CFI at all distances monitored, and water advanced at a similar rate in all the treatments. The Christiansen uniformity coefficient of water content in the soil (CUs) was used to evaluate the uniformity of irrigated water distribution and showed no decrease in AFI and FFI, although irrigation water use was smaller than in CFI. Root development was significantly enhanced by AFI treatment. Primary root numbers, total root dry weight and root density were all higher in AFI than in the FFI and CFI treatments. Less irrigation significantly reduced the total root dry weight and plant height in both the FFI and CFI treatments but this was less substantial with AFI treatments. The most surprising result was that AFI maintained high grain yield with up to a 50% reduction in irrigation amount, while the FFI and CFI treatments all showed a substantial decrease of yield with reduced irrigation. As a result, WUE for irrigated water was substantially increased. It is concluded that AFI is an effective water-saving irrigation method in arid areas where maize production relies heavily on repeated irrigation.

Yonts et al. (2000) mentioned that polyacrylamide (PAM) is used in irrigation water as a method to stabilize soil particles near the surface of the soil during furrow irrigation. PAM was mixed with irrigation water for both surge irrigation and conventional irrigation practices in 1999. Surge irrigation, with and without PAM added to the water during the first irrigation, resulted in reduced or equal furrow advance times when compared to the corresponding conventional irrigation practice. Advance time in surged furrows, previously irrigated and treated with PAM, resulted in greater furrow advance time compared to surged furrows that were previously untreated. When PAM was used in the water for the first irrigation on a coarse textured soil, furrow irrigation advance time tended to be reduced for both surge and conventional irrigation. On a fine textured soil, furrow advance time for the first irrigation was nearly the same for surge, but greater for continuous irrigation when PAM was in the water.

Molden et al. (2002) mentioned that, dried-up and polluted rivers, damaged ecosystems, and poor people without adequate access to water are a few of the most obvious symptoms of what is rapidly becoming a global water crisis. Fueling the crisis are increasing competition for water and water scarcity driven by population growth and additional demands for water by agriculture, cities and industries. IWMI Water Scarcity Studies show that if current trends continue, large areas of the world will face physical water scarcity -- a condition where there is not enough water to meet all agricultural, domestic, industrial and environmental needs. Much of the developing world is already suffering from what we call economic water scarcity -- where a lack of human and/or financial resources constrains the ability to tap the water needed to meet human needs. But there are actions we can take now to resolve the crisis. The objective of this paper is to define the nature and extent of the crisis, and how improvements in agricultural water use are a key part of the solution. The amount of additional irrigation needed in the future is at the heart of the debate on water for food and environmental security. Additional irrigation may help ensure food security, but often at high environmental and financial costs. Increasing the productivity of water in agriculture is an attractive option. By producing more food with less water, water can be made available to other environmental and urban uses. Our research has shown that by increasing productivity of irrigated water by 60% and rainfed agriculture by 30% over the next 25 years, it is possible to produce enough food globally, while reducing irrigation withdrawals. Increasing productivity of water to these levels will require several simultaneous agricultural improvements in the fields of crop breeding, soil and nutrient management, policies and institutions, co-managing water for agriculture and the environment, water management in irrigation, and innovative poverty-focused approaches.

2.2. Irrigation system evaluation:

Ashraf et al.(1999) pre-inferences that the farmer's irrigation performance was poor with an estimated average application efficiency of 44% Numerical simulations showed that by selecting proper irrigation durations and inflow rates, average application efficiency can be increased to 58%. Slope had a significant effect on irrigation performances as runoff volume was 52% larger and sediment losses were eight times greater at the steep site under non-straw conditions. Application of straw mulch was effective in reducing sediment losses by 99 to 100%.

Griffiths and Lecler (2001) determined evaluation of irrigation system performance facilitates objective analysis of the typical as apposed to the potential performance of various of irrigation systems and the respective management criteria, appropriate for local conditions in Zimbabwe. This in formation can also help with the selection of one application uniformly of a system over anther given local constraints. The impact that the can have one crop yield and irrigation efficiency, is further motivation to under take system evaluations.

Oyonarte and Mateos (2003) found that in surface irrigation, water infiltrates into the soil but is also transported over the soil; thus, the spatial variability of the soil hydraulic characteristics is one of the variables determining irrigation performance. Furrow irrigation models rarely consider the variability of the soil intake characteristics. However, such models are more and more for the design, evaluation, and management of surface irrigation systems.

2.3. Analysis and design of furrow irrigation system:

Izadi and Wallender (1985) mentioned that evaluation and design of furrow irrigation systems have been considered functions of intake opportunity time, without considering the effect of varying infiltration. Although roughness, slope and cross section shape of a furrow may vary widely in space and time. Attribute only about a third of the infiltration variability to wetted perimeter differences and the remainder to measurement error and soil variability. Thus, ability to simulate and evaluate furrow irrigation performance with a high degree of reliability is constrained without a clear understanding of the temporal and spatial soil variability.

Khaled and Wallender (1987) simulated advance using a volume balance model with spatially averaged and spatially varying infiltration functions was in close agreement with the observed field advance during the first but not the second irrigation. Cracking of soil was most likely the source of greater variability and the overestimation of intake for the second irrigation. For both irrigations, however the modified infiltration function overpredicted while the branched function underestimated infiltration on Yolo clay loam.

Including a spatially varying, rather than a spatially averaged infiltration function is prefereable since simulated water application uniformity using spatially varying infiltration functions agred more closely with field measured uniformity. However, measured uniformity is less than uniformity calculated from intake opportunity time coupled with infiltration functions or from simulation. Takeing soil moisture measurements and infiltration measurements on the same furrow should improve the agreement between methods, however, this can not be done without interfering with advance. In any case, not all the disagreement would be resolved because measurement error for the different methods is likely different.

Zerihun and Feyen (1992) developed that the FISDEV micro-computer based software package (Furrow Irrigation Systems Design and Evaluation) for the design and evaluation of the three main methods of designing furrow irrigation: fixed inflow, cutback and tailwater recovery systems. It enables the major design parameters of flow rate and spacing to be calculated and optimized in an interactive fashion. The program can also compare two or all of the three furrow designs for a given data set.

Reddy (1994) told that the design problem of furrow irrigation systems considering runoff and drainage water quality was formulated as an optimization problem, with maximization of net benefits as the objective. A power advance function with an empirically derived relationship between the furrow irrigation design variables and relative crop yield were used in the formulation. The generalized geometric programming technique was used to solve the optimal values for the design variables that maximized the net benefits a furrow irrigation system. The optimal efficiency for which the system must be design under a given set of soil, crop, and economic conditions is not known in advance. In the design, the application efficiency was not specified a priori. It was an output from the optimal design. The analysis suggested that it might not be economical to design surface irrigation systems to achieve a high application efficiency that is specified a priori. In the absence of environmental degradation problems from irrigation, it may sometimes be profitable to design surface irrigation systems to operate at less than the standard application efficiency (55-90%) that is routinely used in the design. Formulation of the design problem as an optimization problem would yield the optimal application efficiency that would maximize the net benefits to the farmer under any given set of conditions.

Marlet et al. (1996) found that SEPI-G was developed for the design of furrow irrigation systems and for assessing irrigation efficiency at field level. It is a model to evaluate hydraulic performance combined with a simple water balance model.

Salokhe and Jianxia (1998) found that the net return for water use and furrow irrigation designs (inflow rate and cutoff time) were optimized for both complete and partial infiltration and furrow geometry information using a kinemtic wave hydraulic model and an economic optimization model. A furrow sampled at 10 locations was assumed to represent actual field conditions. Sub-samples were randomly drawn from the 10 samples and returns from water maximized. A furrow inflow rate of 1.6 litres/s and time of cutoff 160 min gave maximum return fromwater (45.14 $/furrow) in the case of complete information. For partial information cases the frequency of designs with inflow rates closer to the optimal inflow rate increased with sample size. A sub-sample with dominating characteristics (high or low infiltration) may lead to extreme designs and greater errors in predicted irrigation performance. To reduce errors, sub-samples should consist of both high and low infiltration characteristics. In general, errors decreased with sample size.

Zerihun et al. (1999) found that the furrow irrigation system design problem is cast in an optimization setting. A structured problem formulation and a pre-solution analysis procedure is presented. The application of the proposed approach in the detection and removal of constraint redundancy and inconsistency, as well as complications related to scale problems is demonstrated. Key solution features, such as solution existence and (non) uniqueness, constraint activity at the optimum, as well as properties of monotonocity of the functions used in the problem definition are studied. The analysis reduced the problem into a form which is easier to solve. A method of multipliers based constrained nonlinear programming (NLP) algorithm is developed for the solution of the minimum cost furrow irrigation design problem. The NLP model includes a subroutine into which the minimum cast design problem is programmed. Solutions of test problems obtained using the NLP model are in good agreement with those obtained using the General Interactive Nonlinear Optimizer (GINO) model. The validity of the numerical solutions of the test properties is further assessed by comparing them with solution features and properties identified in the problem formulation phase.

Camacho et al. (2000) mentioned that surface irrigation is the predominant and most commonly used method of irrigation worldwide. In their study artificial neuronal (neural) networks are used to estimate performance parameters (potential application efficiency, distribution uniformity, deep percolation and runoff fractions) in the design and management of furrow irrigation to achieve required depth along the furrow. The data used were derived from a volume balance mode in which surface and subsurface storage factors were variable with time and obtained through a kinenatic or mixed model. The results obtained suppose acceptable correlation coefficients (>0.88) as compared to the mixed model data. Validation was accomplished through a comparison with the SRFR model ***(Strelkoff, 1999).***

Clyma and Reddy (2000) told that optimal design of furrow, border and basin irrigation systems are presented. Generalized geometric programming selects the optimum application efficiency for maximum net benefits for furrow irrigation. A simplified analysis derived from a generalized objective function selects a minimum cost design for borders. Level basin designs for maximum and 90% of maximum net benefits are selected based upon a system simulation approach. All approaches use defined relationships between system variables and system performance obtained from theory or system simulations. System performance is related to crop production to obtain net benefits. Optimal design now provide a basis for changing farmer management decisions based upon changes in costs or net benefits.

Nimah et al. (2000) determine the impact of furrow compaction on the furrow design parameters. Five treatments were implemented: (1) control, no compaction; (2) one tractor pass; (3) two tractor passes; (4) three tractor passes, and (5) four tractor passes. All treatments were followed by three successive irrigations. Advance time and cumulative intake rate decreased with one pass, and thereafter didn't change. Manning's roughness coefficient decreased by 9% with one pass and after the first irrigation; while, soil compaction increased at 7.5 cm depth and no change was recorded at 22.5 cm depth.

Zerihun et al. (2000) a furrow irrigation system design problem has been formulated in a minimum cost design setting. The design problem has been formulated as a function of three integer valued decision variables. A simple (requires only about 40 lines of code), robust, and capable of finding a globally optimal solution to the design problem.

Sepaskhah and Bondar (2002) indicated that the manning roughness coefficient n is one of the parameters in design furrow irrigation. Its appropriate selection is important for efficient water application in field. They mentioned that the manning roughness coefficient in ordinary and every other furrow irrigations with different inflow rates (0.4; 0.8, and $1.1 ls^{-1}$) and furrow slopes (0.2 and 0.4%) at various growth stages of wheal with different crop vegetation covers were determined on a clay loam soil. The calculation was based on the volume balance equation in the form of a differential equation that was solved with the forward finite difference (method 1) and the secondary backward finite difference (method II) procedures. Comparison of the results obtained from these two methods showed that method I resulted in lower values of n than method II. So, the mean of the values for n from the two method were used for the medium texture soil of the present study. There was no difference between the values of n in ordinary and every-other furrow irrigations. Their results indicated that at the first irrigation, the values of n were high (0.07 – 0.121), but at the second and third irrigations, the values of n decreased by about 60-70%. However, after the third irrigation, the seedling emergence of wheat resulted in increasing the values of n. The minimum and maximum values of n which belonged to the third and seventh irrigations were 0.047 and 0.136, respectively. Finally, two equation were proposed for the estimation of the roughness coefficient for bare and vegetated furrows according to the number of irrigations (up to three before seedling emergence), inflow rates and percentage of vegetation covers.

2.4. Technical and economic comparison of irrigation system:

Bernardo et al. (1988) developed a two-stage simulation mathematical programming model to determine the optimal intraseasonal allocation of irrigation water under conditions of limited water availability. The model was conditions to a representative surface irrigated farm in Washington State's Columbia River Basin. Results from applying the model to a series of increasingly severe water shortage conditions indicated a large potential for water conservation in the assumed production setting. Farm-level water supply reductions of 40% translated to about 10% decrease in economic returns. Income losses resulting from water shortages were minimized through the conjunctive management of irrigation scheduling, irrigation labor practices, and several other short-run responses to water deficits. The combination of crop water simulation and farm-level economic optimization models was shown to be a compatible merger of techniques for representing the engineering and economic irrigation environment.

Gurovich (1992) presented A mathematical model to evaluate alternative design and operation techniques of furrow irrigation. Results obtained with different soil slopes, roughness, furrow length and constant or variable inflow rate are reported in relation to efficiency and the distribution of water depths infiltrated at different points along the furrow. His results showed that the relative impact of the main design parameters and operation techniques when these are modified to enhance the efficiency and uniformity of furrow irrigation.

Langlinais (1992) this study describes the uses of DRAINCALC Release 4.0, a computer aided design tool to expedite drainage and runoff calculations, and to aid the design of open channel culvert and storm drainage systems. The program can be used on any Dos 3.0 or higher operating system.

Bosch et al. (1993) told that the manual presents some of the common open channel structures that cane be found in small irrigations schemes and in small units of larger schemes. It explains the system of water distribution and related structures which are needed to control the flow of structures for flow measurement and for the protection of canals. Common technical problems that are often encountered in the operation as well as the necessity of maintenance and repair works are discussed.

Jocob (1993) found that the Hensall Compost Facility (HCF) processes grain screening wastes generated by 3 large grain cleaning/processing elevators. The HCF utilizes an in-vessel, open channel composting system which can handle 25t of feedstock materials daily.

Yadav and Bhushan (1993)discussed irrigation of former ravines which have been terraced and leveled to make them suitable for arable farming is discussed. The most efficient irrigation system for these conditions is considered to be a combination of open channels and underground pipelines. Schematic diagrams of experimental systems are given and construction costs are tabulated.

Bezborodov (1995) studied of the effect of the length of watering furrows on the environmental and economic results of cotton crop irrigation. When furrow length was increased to 400 m, unproductive water losses due to filtration from canals decreased, the coefficient of land use increased, and the cotton yield, as well as the overall harvest, increased. The environmental situation improved because the danger of a rise groundwater level diminished.

Neikova (1996) told that in the context of break-up and the privatization of large state farms in Bulgaria, farmers need to choose appropriate irrigation systems for their (smaller) fields. Details are given to assist in the restructuring and choice of installation systems, viz. trickle irrigation, furrow irrigation, and overhead sprinkling. Capital investments and annual operating expenses for each type of equipment are calculated and compared, using as an example a unit of 213 decares of peaches. [1 decare = 1000 m^2].

Unami et al. (1997) examined a reliability problem in irrigation canal systems, where the water demand fluctuates stochastically, was examined. A flow of an open channel with control structures was developed to include the lateral withdrawal, in which the flow rate is suddenly changeable temporally and spatially. Steady flow surface profiles for average water demand patterns are discussed. A mathematical model was developed and the concept was applied to the design problem of a reliable steady surface profile.

2.5. Water application:

Somerhalder (1958) found that, the mean annual irrigation requirements to produce 6.6 tons of alfalfa hay per acre were 27.8 in. and 32.2 in. of water for sprinkler and surface irrigation, respectively. Sprinkler irrigation produced the same yields as surface irrigation with one-seventh less water. Most of the differnce is due to the greater amount of runoff from the surface irrigated plots.

He calculated the water application efficiency “Ea” by using the following equation:

$$E_a = (d_s / d) 100 \quad \text{--} (2.1)$$

where:

d_s = water stored in root zone, inches and

d = depth of water to be applied, inches.

His results indicated that the mean values of water application efficiency were 84 and 72% for sprinkler and surface irrigation, respectively.

Willardson and Bishop (1967) mentioned that, the effectiveness of an irrigation water supply can be increased by improving the efficiency of water application. In surface irrigation, water application efficiency is influenced principally by the amount of water applied the intake characteristics of the soil, and the rate of advance of water over the soil surface.

Linderman and Stegman (1971) studded the effect of lengths of run on Water Application Efficiency (WAE). They found that, the appropriate inflow rate that gave the peak efficiency level remained nearly constant over wide range of run lengths. The optimum inflow rates increased as run length was increased. Thus, erosive inflow rates or excessive flow depths become a limiting factor as length of run is increased.

Nicolaescu and Kruse (1972) reported that field trials can be used to determine the exact, time-varying rate of flow to an irrigated furrow and proper length of run that will provide maximum uniformity of water application while eliminating runoff. This flow can be approximated by two or more constant stream sizes, each applied for equal time intervals, facilitating automation of the water application. Design of spile sizes and placement for such an automated system is given.

Kiwan (1996) told that an analytical solution for the optimum design of furrow irrigation systems. The nonlinear calculus optimization method is used to formulate a general from for designing the optimum system elements under circumstances of maximizing the water application efficiency of the system during irrigation. Different system bases and constraints are considered in the solution. A full irrigation water depth is considered to be achieved at the tail of the furrow line. The solution is bases on neglecting the recession and depletion times after off-irrigation. This assumption is valid in the case of open-end (free gradient) furrow systems rather than closed-end (closed dike) systems. Illustrative examples for different systems are presented and the results are compared with the output obtained using an iterative numerical solution method. The final derived solution is expressed as a function of the furrow length ratio (the furrow length to the water traveling distance).

Mailhhol et al. (1996) developed a model to choose the level and timing of water stress suitable to crop phonology to improve the efficiency of supplementary irrigation on crops with high water requirements,. The model was used to predict the effect of reduction of water supply taking into account the sensitive periods of the crop cycle to water stress. By using the Water Balance Model (WBM) coupled with crop yield function the efficiency of a given volume of water can be maximized on the basis of climatic series. This methodology was applied to grain sorghum in the Mediterranean area. Predictions of crop water status and ultimate yield can be given based on a 21 year climatic record and can be used for irrigation scheduling.

Pitts et al. (1996) provided the irrigation with information to improve irrigation system performance based on distribution uniformity. The mean value of distribution uniformity was 64%, water cost averaged 11 cents/m^3, and the average annual application depth was 0.7 m. Mean distribution uniformity varied based on system type with 65% for agricultural sprinkler, 70% for micro irrigation, 70% for furrow and 49% for uon-agricultral turf sprinklers.

Souza and Scalloppi (1999) studied performance of the continuously reduced inflow regime in furrow irrigation. They found that water application efficiency decreased in the regime without reduced inflow for continuous and surge flows, it was attributed to an increase in runoff percentage at the end of the furrow. However, when continuous reduced inflow was adopted the application efficiency increased, mainly for high reduced inflow. It was can concluded that the system constitutes an advantageous alternative for water application in the furrow compared with traditional systems and it facilitates the application of gross residual water to the traditional vegetable cultures, even for consumption without treatment.

Zerihun et al. (2000) told that application efficiency is the primary criteria for furrow irrigation system design and managementThey also indicated that optimality conditions were derived for the cases in which application efficiency is a function of either furrow length or furrow inflow rate. The optimality conditions have been evaluated by comparing their output with the output of a surface irrigation simulation model.

Lentz et al. (2001) mentioned that water-soluble anionic polyacylamide (PAM), a nontoxic polymer, is employed in furrow irrigation to control soil erosion and increase infiltration. They hypothesized that post-irrigation deep percolation and preferential-flow patterns for the and PAM-treatment would differ from that of the conventionally irrigated (CI) furrows. Portneuf silt loam plots 179 m long were planted to corn and irrigated using either CI or PAM treatment. They added PAM to advancing irrigation furrow streams at 10 ppm. Inflow rates during furrow advance were 3X greater than that of conventionally irrigated furrows. Vacuum assisted percolation samplers at 1.2 m depth and neutron probe access tubes were installed at locations 30 m down furrow to monitor soil water flux and soil wetting patterns. Daily deep percolation volumes were collected after two irrigation events in 1998, and analyzed for nitrate-N and CI concentrations. Two general patterns for daily percolation rate emerged. Under CI, percolation rate started high the first day after irrigation, declined during the second and third days to a value about half that of the first day, then rose to a second peak between 6 and 7 days after irrigation. PAM percolation rate started low on the first day after irrigation, peaked at about twice the initial rate on day two or three, declined through day four or five, then rose to a second peak between 6 and 8 days after irrigation. Water moved rapidly downward from CI furrows after irrigation, and included bypass flow that diluted nitrate concentrations in deep percolation water. PAM treatment inhibited initial rapid downward movement of applied water, possibly by reducing preferential flow.

2.6. Infiltration rate:

Miller et al.1963) found that more passing of agricultural equipments markedly increased bulk density of the surface and decreased in infiltration rate.

Lymans and Rishop (1967) told that infiltration condition differ for each irrigation time. Infiltration is one of the primary factors affecting water advance and there force distribution of water over the surface of the shape of the optimum advance curve. Despite these difficulties, irrigation by surface methods can be efficient.

Hansen et al. (1979) stated that the infiltration of soils, of great importance to irrigators, in the time rate at which water will percolate into soil, or rate of infiltration usually, the infiltration rate is much higher at the beginning of rain or irrigation than it is several hours later it is influenced by soil properties and also moisture gradient. Moisture tension, explained in the following chapters, may be zero near the surface of soil shortly after wetting and may be very high a few centimeters below, thus causing a large down ward force (in addition to gravity) pulling the water into the unsaturated soil. Several hours after wetting, these differences in tension may be very small and gravity then becomes the dominate force causing infiltration. The decrease of infiltration with time after wetting a soil is of importance in rainfall-run off studies and in irrigation water standing on gravely or coarse sandy soils percolates into the soil so rapidly that the water surface may be lowered several inches on hour on fine-textured clay soils, water may collect and stand on soil, seemingly with very little infiltration, for many days. Desirable infiltration rates are between these two extremes. A convenient means of expressing infiltration is in terms of centimeters lowering of water surface per hour for example, if a hectare of level and at 90' clock the water is covered with water to a depth of 5 centimeters and at 100' clock the water is but 2 centimeters deep, the infiltration rate is 3 centimeters per hour, neglecting evaporation losses.

Radhey et al. (1972) told that the infiltration rate depends on the physical properties of the soil, such as structure, texture, porosity, moisture content of the soil, degree of compactness, colloidal and organic matter, entrapped air, temperature distribution in the soil and several other chemical and biological characteristics. Studies on infiltration have shown in general that the in take rate is initially high and that it decrease with time.

Albert et al. (1981) told that, the dimensionless solution of advance and recession in level basins was extended to show the distribution uniformities for a wide variety of conditions. This was then transformed into two representations of distribution uniformity that are more useful for designing and managing level basins. One solution displays the effects of net infiltration depth and the necessary infiltration opportunity time on distribution uniformity. The other displays the effects of field length and flow rate on distribution uniformity.

Albert and Dedrick (1981) found that, distribution uniformity can be calculated by using two method, power function method and brunch function. They recommended that the power function method requires values for the recession time and the infiltration exponent. The branch function method requires values for the final infiltration rate and the average depth of water infiltrated.

Ronald et al. (1983) used a mathematical model to describe the advance phase of surface irrigation the model incorporates zero-inertia theory, meaning that the acceleration terms in the equation of motion are neglected. By scaling the variables of the problem, the zero-inertia equations were nondimensionalized, and a set of five dimensionless parameters was derived. Two of the parameters characterize channel geometry and three parameters are functions of the constants of the modified Kostiakov infiltration equation. For a given set of values of these parameters, there is a unique curve relating dimensionless advance was found to be quite insensitive to the two dimensionless channel geometry parameters. As a result, these advance relationships could be presented graphically as a function of only the three dimensionless infiltration parameters.

Schwankl and Wallender (1988) said that the incorporate infiltration as a flow depth dependent stochastic variable in a a furrow simulation modle and investigate its impact on irrigation performance. They developed zero-inertia furrow irrigation modle to run on an IBM-Compatabible personal computer. The depth gradient term of the momentum equation is approximated by averaging over the wetted length of furrow, thus simplifying the simulation. Model simulation at predetermined space increments rather than at specified time increments was utilized. Spatially-varying infiltration and temporally- and spatially- varying wetted perimeter effects on furrow advance and infiltrated water distribution were investigated.

Fonteh and Podmore (1994) studied furrow irrigation with physically based spatially varying infiltration. They indicated that a kinematic wave furrow irrigation model in which a physically based infiltration equation could be spatially constant or variable was developed. The model was used to study the effects of spatial variability of infiltration on furrow irrigation performance. The infiltration sub-model was based on the Green and Ampt equation, and the one-dimensional equation of horizontal infiltration. Geostatistics were used to characterize the spatial variability of infiltration along the furrow. Comparisons were made between results predicted by models with constant and spatially varying infiltration and actual results. Comparisons were made using the following irrigation performance parameters: application and requirement efficiencies, tailwater ratio, distribution uniformity and the deep percolation ratio. The results indicate that simulation models which incorporate spatial variability of infiltration predict irrigation performance parameters closer to the actual values than those that assume spatially constant infiltration.

2.7. Energy-saving irrigation systems:

Heermann et al (1969) studied surface-roughness characterization in relation to furrow-irrigation systems. They found that surface roughness and related resistance to flow affect rate of water advance, rate of recession, and indirectly infiltration depth. Efficient irrigation plished only by the proper combination of these three factors. Quantification of surface roughness and associated hydraulic-flow resistance is a necessary step in reaching rational design criteria.

Comp et al. (1984) found that the selection of the best combination of management practices will depend upon energy costs for the respective operation in relation to the yield increases provided.

Roberts et al. (1986) mentioned that the adoption of new or modified irrigation systems by farmers is generally determined by the economic efficiency of these systems rather than the energy use efficiency. In seeking alternative irrigation systems with reduced energy requirements, the economic costs must be considered..

2.8. Factors effect on surface irrigation:

Whittlesey et al. (1986) said that, major factors that influence irrigation efficiency include rooting zone depth, soil water holding capacity, irrigation period and frequency, stream size and length of run, and application uniformity. Some alternative irrigation systems in common use are discussed and estimates of their efficiency for major crops tabulated. The effects of texture and slope on efficiency are emphasized. Crop application requirements are listed and deep percolation losses assessed.

Katopos et al. (1990) estimated surface irrigation parameters. They mentioned that, surface irrigation parameters con be classified into three categories. The first group consists of geometrical factors, such as field dimensions and elevations and furrow or border cross-sectional shape. In general, these parameters are determined during design of the system. The second set of parameters represents the soil and crop factors, infiltration and roughness. Infiltration has a significant influence on the water advance and recession relation, as well as the infiltrated profile. Roughness affects the advance and recession, but generally does not influence directly the infiltrated profile. The third set of parameters represents the management alternatives available to the irrigation. These include the inflow hydrograph, typically represented by inflow rate and cutoff time, and the soil moisture deficit at the time of irrigation, or the management allowed deficit (MAD).

Schmitz and Edenhofer (1991) presented a new modeling approach for surface irrigation based on analytical solutions of both the zero-inertia equations and the Richards equation. The approach is applicable to the simulation of border and furrow irrigation and may simplify certain numerical models, results from the model compared favourably with field data as well as with a numerical model.

Scaloppi et al (1995) used a volume balance approach to determine the parameters of the Kostiakov or modified Kostiakov infiltration equations in border and furrow irrigation. The approach requires measured data from the advance phase, the postadvance (wetting) phase, or both, resulting in three different procedures to characterize infiltration. Using the entire field length the procedures provide infiltration parameters that are more representative of an actual irrigation. The volume balance computation performed by the end of the wetting phase makes it possible to determine the accuracy of each equation that can represent the infiltration process for a particular application. Inflow discharge, water front advance, average flow cross-sectional area and outflow discharge are the required field data. Several mathematical approximations are suggested in order to simplify the field work and the amount of computation. The use of empirical factors to improve data fitting is discussed. By providing irrigation system performance information during an irrigation, this procedure can be easily adapted to guide decision during real-time operation.

2.9. Water uptake by root:

Linderman and Stegman (1971)indicated that soil moisture deficits at the time of irrigations depend on the irrigation regime (i.e., the level of available moisture at which irrigations are begun) the root zone depth and the soil water holding capacity. Influences of deficits ranging from 2 to 6 in (5.08 to 15.24 cm). The peak efficiencies were attained with a relatively narrow breadth of inflow rates. As soil moisture deficit was increased, smaller inflow streams were required to attain the maximum efficiency level.

Stockle and James (1989) estimated corn yields by the Stockle and Champbell model for the different soils, soil water contents at planting, rooting depths and irrigation levels. Yield for a non-irrigated treatment is also included. Their results showed that yields declined as the irrigation level decreased and that yield declines for the loamy sand soil were larger than those for the soil loam. When water storage in the soil was limited due to a shallow rooting depth and/or a half depleted profile at planting time the yield decline with irrigation level was more dramatic.

Gardner (1991) showed that a high root density can be important for the uptake of immobile nutrients such as phosphorous but is not so important for mobile nutrients such a nitrate. A high root density near the soil surface may be ecologically useful where water is limited. The higher the root density, the thinner the uptake zone should be for a given transpiration rate. Just below the soil surface, a higher rate of uptake per unit volume of soil by the plant roots will result in a lower loss of water to evaporation.

2.10. Irrlgation Coveyance :

Ley et al (1984).indicated that 40 % of water might be lost from unimproved field ditches.

Bos et al. (1984) summrized the conveyance efficiencies of different deliverysystem (canals)in the following teple.

Table2.1: conveyance efficiencies of different delivery systems

Waterway	**Conveyance efficiency %**
Unlined cananls	70-80
Lined canals	80-85
Unlined large laterrals	80-85
Lined large laterals and unlined small laterals	85-90
Small lined laterals	90
Pipelines	100

Shawky et al (2004) showed that different projects and experiments have proven that the a verage overall irrigation efficiency is about 50 %. Most of water losses occur in mesqas, marwa and field level.

2.11. Flow Measurment in open canals :

Punmia (1981). said that Measurment of discharge in open canals can be measure by using some methods as follows :-

1) Area-velocity method

the discharge passing through the canal at any sectionis evidently equal to the product of the area of cross-section of the canal and the mean velocity of flow.

2) Weir Method

This method is used specially when there is some Masonry work located at any section of the canal.

3) Meter Flume menthed

The principal of use of meter flumes on canals is similiar to ventury meters in pipes on some channels, meter flumes are specialy costructed for discharge measurments.

4) Chemical method :

This is an approximte method in which a solution of known strenght of some chemical, usually salt, is introduced uniformly over a cross-section, at a known rate.

Bos et el. (1984). mentioned that there are sereral methods of measuring flow in open irrigation channels. Flow rate is measured using either the volumetric, velocity-area, control section, or dilution methods. Flow volume can be determined from flow rate measurments they explain the mentioned methods as follows :-

1) Volumetric Method

In this method, the time required for the flow to fill a known volume container. The flow rate is determined by dividing the volume of the container by the time required to fill it.

2) Velocity-Area method

The velocity-area approach involves measuring the velocity and cross sectional area of the channel and using the following equation to compute the flow rate as follows :-

$$Q = KVA \quad \text{--} (2.1)$$

Where :

Q = Flow rate, l/s (gpm);

V = the average flow velocity, m/s (ft/s);

A = cross sectional area , m^2 (ft^2)

K = unit constant (K=1000 for Q in l/s, V in m/s, and A in m^2. K= 448.8 for Q in gpm, Vin ft/s, and A in ft^2)

3) Control sections :

This method involves the use of natural or constructed installed control sections with stable depth of flow (stage) versus dicharge (volumetric flowrate) relation ships. Discharge is determind from measurments of stage using the stage-discharge relationship for the canal section.

4) Dilution methods :

The dilution method involves injecting a known amount of a chemical, fluorescent, or redioactive tracer into the flow and measuring its dilution after it has flowed far enough downstream to mix completely with the water and produce a uniform concentration . No measurements of area or distance are required , since the total flow is determined directly.

Lenka (1991) Said that, measure water in the farms can be grouped into (a) Direct methods, (b) volocity area method, (c) using weirs and orfices, and (d) tracer method.

2.12. Advantage and Disadvantages both of earth and lining canals :

Santosh (1976) mentioned that most of the canal, constructed to carry this castly irrigation water are unliend and hence a large part of it is lost in percolation and absorpation a seepage loss. No doubt, there are regions where the soil is such that seepage losses are very small, and there is no justification for lining them, but at the same time it is also true that there are areas where 25 to 50% of the water is lost in seepage. This is avery serious loss and proportionately reduces the irrigation potetial of the same water and must therefor be saved. The seepage can be avoided by linig the canals , He sumrized the advantages f lining as fllows..

1) Seepage control

2) Prevention of water – logging

3) Increase in channel capacity.

4) Increase in commanded area.

5) Reduction in maintenace costs.

6) Elimination of flood a angers.

Hansen. et al, (1979) said that irrigation canals are lined for purposes of the following purposes:-

1) Decreasing conveyance – seepage loeees
2) Providing safety against creaks
3) Preventing weed growth
4) Retarding moss growth
5) Decreasing erosion from high velocities
6) Cutting down maintenance costs
7) Reducing drainage problems
8) Increasing the capacity to convey water

They added that the limiting velocity together with corresponding values of roughness , (n) , the valus shown apply the water depths of 1 meter or less in canals that have been brought to capacity gradually . For depths of water over

1 meter , the velocity should be increased 0.15 meter per second. For canals with sinuous alignment , a reduction of 25 percent is recommended.

Punmia (1981) showed that the earth canal have mean velocity raning from 0.3 to 1.1 m / s. In contrast to this, a lined canal may have velocity ranging from 1.8 to 2.5 m / s.

Thay mentioned that the disadvantages of earthen canals can be summrized as follows :-

1) Low velocity of flow
2) Consequent seepage
3) Bulty
4)Weedy
5) Leaky
6) Productive of water logging
7) Productive of malerial conditions.

They also added that, the advantages of lining canals may be summrized as follows :

1)To minimise the seepage losses in Canals.
2)To increase the discharge in the Canal section by increasing the velocity.
3)To prevent erosion of bed and side due to high velocities.
4)To readuce maintenance of Canals.
5) Anti water logging measure.
6) Increase in stability of banks.

7) Increase in Canal water power.

8) Economical distribution.

9) Improvement in water quality.

Disadvantages of lining canals :-

1) High initial cost, the lining canal requires aheavy initial investment.

2) Difficulty in repairs, if the lining is damaged due to some reasons, it is difficulty to repair.

3) Absence of berms, alined section is generally constructed without berms. The moving vehieles, pedes trians etc. are laible to fall in the Canal.

4) Diffculty in shifting the position of outlets, lining in the canal is a permanent stracture. Hence it is difficult to change or shift the position of outlets once fixed in the initial stage during lining.

Elkady et al. (1984)studied advantages and disadvantages of canal linings, lining materials pertinent to Egyptian conditions, factors, affecting lining selection and a descripition of field trials conducted in Egypt. They indicated that to estimate lining costs and delineate Construction techniques for the various lining materials three Canal sizes were selected for study, with design discharges of 0.035, 0.7 and 7.0 m3/sec respectively. A total of 7 lining materials have been considered, with a total of 15 variations of construction techniqes. Design and construction costs have been estimated for the three canal sizes and for various lengths of canals until the marginal construction cost approaches its lowest level. Annual maintenance costs have also been estimated for these canal lengths. Potential benefits have also been estimated, though specific benefits require precise evaluation on a site specific basis. For the smallest canal size considered, concrete lined bricks, cast in-place concrete and asphalitc concrete appear to be the three most economically viable method of lining. For canal carrying approximately 0.7 m^3/s., cast in place concrete, 10 ml buried poly-vinyl chloride and soil-cement are the most advantageous economically. While for the largest canal size considered, soil cement 10 or 20 ml poly-vinyl chloride and cost-in-place concrete are the most viable lining methods. It is recommended that if a nation-wide lining program is to be implemented, then cast-in-place concrete lining, using slipform construction technique be adopted due to thir anticipated life span, ease of maintenance and compartive cost advantage.

Punima and Pande (1990) found that losses in Canal comprise evaporation from the surface and seepage through the bed and sides of the drains.

Loss due to evaporation from a canal system depends upon the climatic condltions of the region and hence it can never be prevented however of the losses by evaporation forms a minor part, hardly 13 to 20 % of seepage loss is not significant.

The magnitude of seepage losses from canal will be evident branches are 15 %) for distributarles and minors 20 % and for water upper courses 22 %. The total evaporation losses are less than 1 %. On upper Bari Doab Canal system, the losses estimated for main canal and branches are 12.2 %, for aistributaries and minors 9.2 % and for water courses 12.5 % losses in canal irrigation U.P. are assessed as below :

Table 2.3:Losses in canal irrigation as follows:

Type of soil	losses in canal irrigation %
Sandy Soil	25 to 50 %
Sandy leams	15 to 25 %
Fine sandy leams	10 to 20 %
Clay leams	5 to 15 %.

The seepae loss from the Canal occurs in two ways nawely :

i) Absorption ii) Percolation

Laycock (1993) showed that the construction in Pakistan of minor canals of capacity 30 cusecs and less using segments of parabolic section may enable, the construction of canals of high standard. The approach is claimed to provide canals that will not disintegrate, will not leak, will greatly facilitate water management and maintenance, and will last for a , hundred years. In the North West Frontier Province of Pakistan, minor canals and watercourses serving a total of 200000 acres are due for lining over the next ten years. Four pilot projects have proved highly successful. The capita! cost of parabolic linings for small canals is less than more traditional alternatives and their life is longer.

Mohammad et al. (1993) found from analysis of seepage / loss data collected from the canal shows 4.38 (plus or minus 0.34) cfs/msf for the unlined reaches, and that / for the lined reaches losses are 2.97 (plus or minus 0.3) cfs/msf of wetted area-a 30% reduction due to lining. Design loss rates were 8 cfs/msf for unhncd parts of the canal and 2 cfs/msf for lined parts. Using the seepage rates found in this investigation, the expected total seepage loss from the project of 385 cfs, was reduced to 327 cfs. The seepage loss rate determinations were examined critically for errors, and were found to be of satisfactory accuracy. The difference in average seepage between brick-lined and concrete-lined parts of the canal was practically insignificant. The measurements also show that there is little correlation between seepage loss rate and inflow discharge into the canal.

Weller and McAteer(1993) said that there are three commonly used seepage measurement methods (ponding, seepage meter and inflow-outflow method), and the accuracy that can be expected from them, are discussed. Errors in seepage estimates derived from the inflow/outflow method, using velocity area discharge measurements, were analysed based on data collected from canals in India. It was found that estimates of errors in seepage rates in canals are unduly pessimistic when based on studies of errors made on velocity-area discharge measurements made in natural rivers. The paper provides guidance on planning seepage measurements so that errors are minimized and the maximum benefit is obtained from expensive field data collection exercises. It identifies ponding as the most reliable of the three methods to obtain realistic estimates of seepage losses.

Aziz (1993). Found that improving the water efficiency of Egypt's irrigation system offers the best solution to its problem of how to increase food production, Egypt is lining canals and local water courses (mesqas), as well as installing low pressure irrigation pipelines to improve water delivery efficiency, to reduce operation and maintenance costs and improve/the utilization of land. Several kinds of channel lining have successfully been used in Egypt (concrete; rock pitching- rock pitching with impervious membrane, rock-filled gabions, precast concrete J-sections). Such lining is extensively used in the new development areas, but has been limited in the established irrigation areas. The

Irrigation Improvement Project plans to use concrete-lined mesqas or low pressure pipelines to deliver water to new water user associations.

Junejo (1993) showed that seepage losses are heavy in the irrigation channels of Pakistan's Sind province, which are mostly unlined i.e. earthen. The Command Water Management Project was launched during 1986 to carry out lining of small earthen channels in two systems of the Rohri Canal. This canal is an offtake of the Sukkur Barrage. Channels of up to 30 cusecs discharge were lined, and channels of more than 30 cusecs discharge were rehabilitated. The cost of lining per mile of the channel having a wetted perimeter of approx equal to 12 feet was approx equal to Rs 1.6 million. Channel lining of approx equal to 140 miles was estimated to save approx equal to 50 cusecs. The benefits of lining include: (1) saving of seepage losses etc.; (2) equitable and assured supplies of irrigation water and (3) improved flow conditions in the channel due to proper section, gradient and smooth surface etc. The agricultural and economical benefits include: (1) extra cultivated area due to saving of water; (2) increased crop yield due to assured and timely application of water; (3) improved financial situation for farmers; (4) increased revenues: and (5) significant reduction in the maintenance cost. Channel lining is considered to be economically viable and it is concluded that the Government of Sind should do more.

El-Shipini (1993)mentioned that seepage losses from the Nile, and from main and branch canals form a considerable part of the total outflow downstream from the High Aswan Dam (55.5 billion m^3/year). Seepage from the Nile goes to a shallow aquifer where it can be pumped. Seepage from . the canals network (total length 40000 km) and drains network (17000 km) recharges the deep and shallow aquifers. The older irrigation canals exist in the clay cap of the Nile valley, while most new development has taken place in sandy soils at the valley fringes. Which slope upwards. The main function of canal lining in the new land is to control canal seepage and at certain places to prevent low quality flow from irrigation schemes in the uplands to enter a canal. For drains, lining is installed mainly to protect groundwater from contamination. There is a need to raise conveyance efficiency through proper lining techniques and materials. This paper discusses the history of canal lining in Egypt and focuses on some lining research studies in progress, and on some case studies. Recommendations for lining materials include using synthetic materials, geotextiles and gabions.

Islam(1998) described the results of ponding tests to observe seepage losses in lined, and, unlined canal sections and to investigate what type of lining materials would be more effective, durable and suitable for the construction of irrigation canals for the Teesta Barrage Project (TBP) in Bangladesh. Ponding tests were carried out in 10 lined and 4 unlined canal sections at the test site of the Bangladesh Water Development Board during the wet (monsoon) season of 1991. and repeated during the dry (winter) season of of 1992. The linings used for the 10 canal sections were brick lining on compacted soil, brick lining on cement a mortar, tile lining on cement mortar, cast in situ concrete lining and asphalt lining on cement mortar. Five of the lined and 2 of the unlined canal sections represented secondary canals with a flow of 1.275 m^3/s and the remaining 5 lined and 2 unlined canal sections represented tertiary canals with aflow of 0.567 m^3/s.Ponding tests revealed that the unlined canal sections had the highest rate of seepage loss. The brick lining on compacted soil had the highest rate of seepage loss, followed by brick lining on cement mortar, tile lining, concrete lining and asphalt lining. Though the asphalt lining had the lowest seepage loss rate, considering cost effectiveness, durability; suitability, maintenance and other problems, cast in situ concrete lining was the most suitable lining and is recommended for widespread application in the construction of proposed irrigation canals of the TBP in Bangladesh.

3. MATERIALS AND METHODS

The present work was carried out at El-Karada Station, Kafr El-Sheikh Governorate during Summer season of 2003. Table 3.1 indicates the mechanical analysis of the soil and the soil texture was clayey.

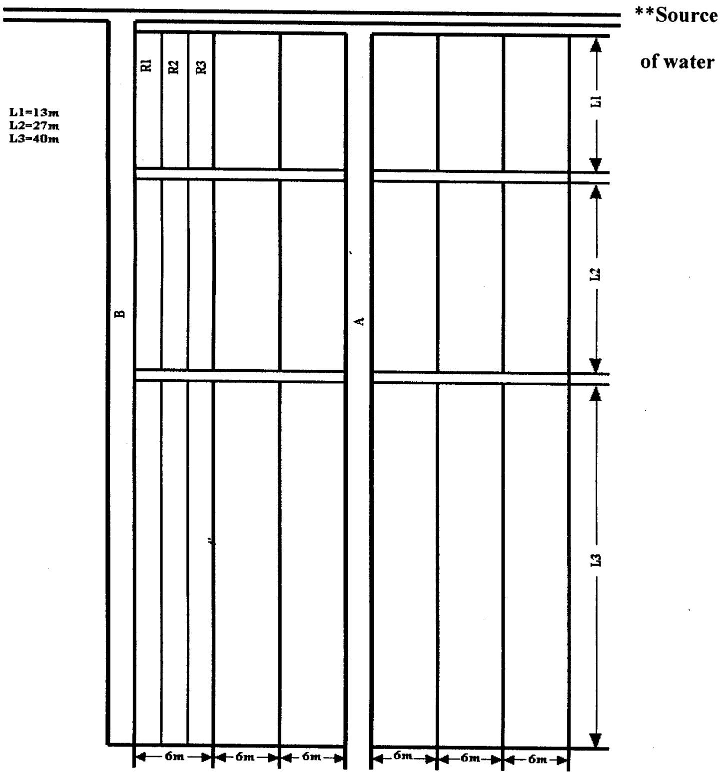
Table 3.1: Mechanical analysis of experimental site.

Soil depth, cm	Particle size distribution			Texture	Bulk density	Field capacity, %
	Sand, %	Silt, %	Clay, %			
0.0 – 15	15.60	19.35	64.97	Clay	1.10	44.80
15 – 30	20.40	14.30	65.30	Clay	1.21	41.45
30 – 45	17.09	17.00	65.01	Clay	1.28	39.27
45 – 60	13.05	15.73	66.13	Clay	1.30	37.20

3.1. Experimental layout:

All agricultural practices (weed control, fertilizer and pesticide) were the same as recommended except the furrow length and the irrigation treatment under study. The field was ploughed by mounted shares l plough on Fiate tractor 119.36 kW (160 hp); the plouhing depths were 20 cm. Traditional leveling was used. The furrow spacing was designed to be 0.7 meter in order to suit the flow rates used for testing. Calcium super phosphate 16% P_2O_5 was added before sowing with a rate of 2 kg/fed. Ammonium nitrate (33.5% N) was added with a rate of 90 kg/fed, divided in two equal doses after thin and sucand irrigation. Maize TWC 122 varity was sown in June 24, 2003.

The experimental treatments were arranged in split-split plot design with three replicates as shown in Fig. 3.1. The main plot was assigned as two irrigation methods (irrigation through earth canal and irrigation through canal lining). The sub plot treatments were the furrow lengths of 13, 27 and 40 m respectively. The sub-sub plot treatments were three different of irrigation water flow: 1; 1.5 and 2 m^3/min



B=Lining canal

A=Unlining canal

Fig. 3.1. Schematic diagram showing the irrigation treatments.

The water flow rate into a filed or furrow is an important design factor. It must be carefully balanced against the soil type and slope so that erosion is minimized and against the field slope and length so that the water reaches the end in a reasonable amount of time. Operating the system at flow rates below or above the design flow rates can lead to inefficient and nonuniform applications. Once the water reaches the end of the field, growers must manage the inflow to reduce tailwater runoff losses. The irrigation intervals were 15 days after the pest irrigation (El-Mohaya).

3.2. Water management:

3.2.1. Soil moisture monitoring:

. The value of soil moisture monitoring is directly related to the ability of the irrigators to control their irrigation applications. Soil moisture monitoring is most effective when used with an irrigation scheduling program.Soil moisure

content was determined at different soil depths by using gypsum block, its dimensions were 3 cm diameter and 3 cm height as shown in Fig . 3.2.

Soil moisture meter as shown in Fig. 3.3 was used to measure the available water in the different soil layers (0.0 – 10; 10 –20; 20 – 40 and 40 – 60 cm) before and 2 days after each irrigation. Soil samples were taken and dried at k(105 °C)for 24 h. at the same time to drive the calibration equation 3.1. to discrip the relation ship between available water and soil moisture content by using excel program computer. The relation ship between moisture content and available water is shown in the following equation:

$$Y = 1.1745x - 2.1749 \quad (3.1)$$

Where: y : Moisture content, %, and

x : Available water,

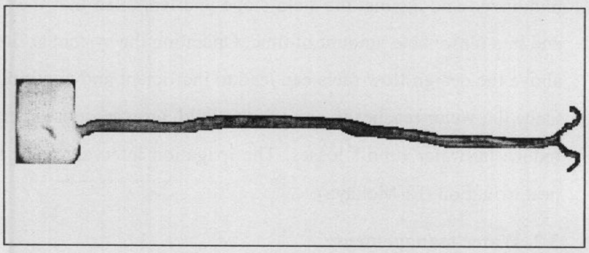


Fig.s 3.2. Gypsum blocks

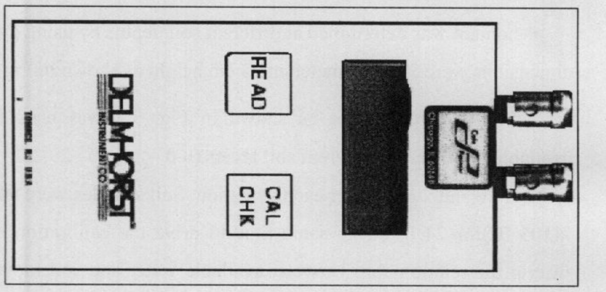


Fig .3.3. Soil moisture meter

3.2.2. Applied irrigation water:

The volume of water applied for each feddan plot was calculated by the following equation (Eid, 1998).

$$Q = q \times t \times n \quad \text{------------------------} (3.2)$$

where:

Q : Applied irrigation water, m^3/fed

q : Discharge m^3/min;

t : Total irrigation time, min/fed, and

n : Number of irrigation per season.

3.2.3. Infiltration rate:

Double ring infiltrometer was used to measure infiltration rate. The diameter of the inside ring was 29 cm, and 50 cm height, while the outer ring has a diameter of 40 cm and the same height. The infiltrometer was placed in the chosen site, faraway the roads and canals or area that way have been affected by animals or machinery traffic, to avoid the horizontal movement of water. The distances between the two rings were filled with water that moved indirection from the inside ring to the soil vertically.

The infiltration rate was computed as follows ***(Hansen, et al. 1979)*:**

$$I.R = d/t \quad \text{------------------------} (3.3)$$

Where :

I.R = Average value of intake, cm/h;

d = Water depth that entered to the soil, cm, and

t = Elapsed time, h

3.3. Statistical analysis:

Split-split plot design was used in statistical analysis where main plot was irrigation systems. Sub plot was furrow length and sub subs plot was flow rate. The mean values were compared by L.S.D. test and Duncan multiple range test.

3.4. Crop yield and its components:

3.4.1. Leaf area index (L.A.I):

Leaf area was measured by using Leaf area measuring set (LI-3100) as shown Fige .3.5. Leaf area index was calculated according to the following equation ***(El-Zeiney et al., 1989).***

L.A.I. = Leaf area per plant, cm^2/spacing area per plant, cm^2

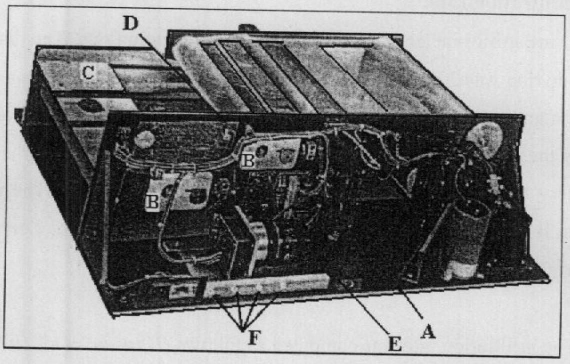


Fig. 3.5. Leaf area measuring set (LI-3100).

a : Main printed circuit board (paragraph 1–1c);
b : Rear sliding bearing blocks (paragraph 2–3a);
c : Sample guides (7.5 cm) for 0.1 mm^2 resolution;
d : Decimal selector switch to the 0.1 mm^2 position;

e : The 105 mm lens in place for 0.1 mm^2 operation, and
f : Screws on outer camera pressure rail.

3.4.2. Root volume:

Root volume was determined from the volume of water displaced by immersing the root sample in the graduated cylindrical beaker filled with tap water. It was measured at 60 days, after 1 st irrigation.

3.4.3. Corn yield:

Five plants from the central furrow at each treatment were randomly chosen to determined the yield for plant; the average of plant yield was multiplied by number of plants in feddan. (24000 plant/fed.).

3.5. Water use efficiency (WUE):

Water use efficiency 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:

$$\mathrm{WUE} = \frac{y}{W_a} \times 100 \qquad (3.3)$$

Where

WUE = Water use efficiency, kg/m^3,.

y = Total grain yield, kg/fed, and

W_a = Total applied water, m^3/fed

3.6. Water management:

3.6.1. Irrigation control:

Irrigation water taken from main canal to weir through iron gate its dimensions is 1m x 1m. The constant head was calculated by using a rectangular sharp crested. The irrigation flow rate was calculated using the following formula ***(Musaued, 1967):***

$A = CLH^{3/2}$ -- (3.4)

where

A = Water discharge, m^3/min;

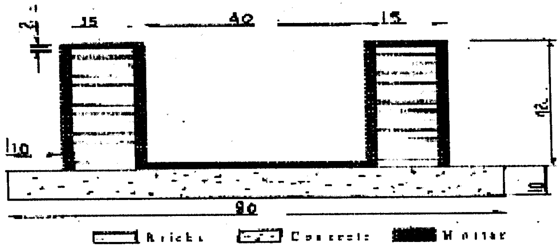
L = Length of the cresting, m;

H = Water head, m and

C = An empirical coefficient that must be determined from discharge measurements (0.3).

3.7. Conveyance effieiency :

The cross-section of lining canal was rectangle as shown in Fig (3.6)



Dimensions by cm.

Fig. (3.6) : Cross-section of lining canal

Rectangular weir was used in the present study to measure the irrigation water flow rate. The following equation was used to calculate the flow rate through open channel (Khurmi, 1982) :-

$$Q = \frac{2}{3} C_d b \sqrt{2g} \left(H_2^{\frac{3}{2}} - H_1^{\frac{3}{2}} \right) \quad ....3.5$$

Where

Q: Discharge over the weir m^3/S.

C_d : coefficient of discharge, (0.6.) dimenation less,

b : width of the notch, m

H_2 : Head of water above the notch, m and

H_1 :Head above the bottom of notch, m :

The cross section of earth canal was measured and summrized as shown in Fig 3.7

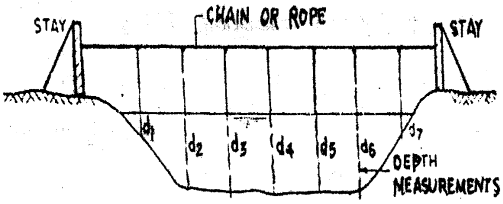


Fig. 3.7 : Cross section of earth canal

In case of earth canal, triangular weir equation was used to measure the irrigation water flow rate according to Khurmi(1982)as following :

$$Q = \frac{8}{15} C_d \sqrt{2g} \tan \frac{\theta}{2} H^{\frac{5}{2}}$$

Where :

H = Height of the water above the apex of the notch, m;

Q = Discharge over the weir, m^3/ s,

θ = Angle of the notch, and

C_d = Coefficient of discharge dimenation less.

Conveyance efficienccey was calculated by using the following eqution:

$$C.E = \frac{Q_2}{Q_1} \times 100$$

Where :

C E = Conveyance effieiency, % ;

Q_2 = Flow rate at field, m^3/s and

Q_1 = Flow rate at source, m^3/s.

4. RESULTS AND DISCUSSION

4.1. Applied irrigation water:

The number of irrigation during the whole season were five additions to sowing and El-Mohaya irrigations.The amount of irrigation water that added to each treatment during the season is given in Table 4.1 and illustrated in Fig.4.1.

The results indicated that the average value of saved water was 190 m^3/fed (6.48)% for lining canal as shown in Fig 4.1 compared to unlining canal where the average value of irrigation water that added under canal lining irrigation method was 2591.44 m^3/fed . season.The highest value of applied irrigation water was 3062 m/fed.season was obtained at 40 m furrow length and 1 m^3/min water discharge for unlining canal.while the lowest value was 2331m/fed. season that obtained at 13m furrow length and 2m/min water discharge for lining.

Table 4.1: Effect of discharge, canal type and furrow length on applied irrigation water.

Canal type	**Discharge, m^3/min**	**Applied irrigation water. m^3/fed.season**		
		Furrow length, m		
		13	**27**	**40**
Unlining canal	**1**	2871	2981	3062
	1.5	2692	2916	3010
	2	2600	2851	2975
Lining canal	**1**	2600	2722	2800
	1.5	2490	2527	2756
	2	2331	2462	2625

The preivous table indicate that, increasing furrow length tended to increase the total applied water in both of unlining and lining canals. This main that

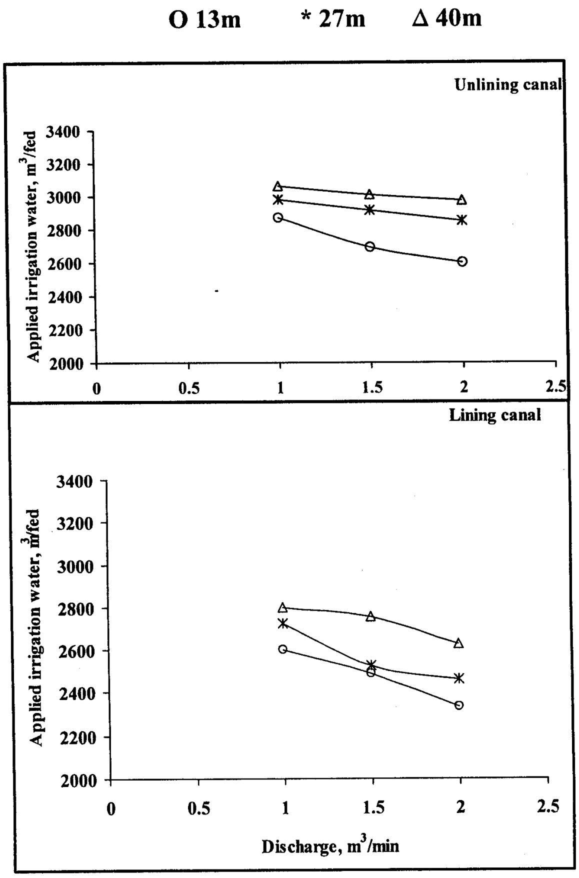


Fig 4.1 : Effect of discharge, canal type and furrow length on applied irrigation water, m^3/fed

the loses in irrigation water deep percolation increased by increasing furrow length due to increase the standing time of irrigation water in the soil surface aspicially in the furrow beginning.

Also,both of applied water and irrigation water losses were decreased by increasing water discharge because. the appling time was decreased by increasing disbrescy.

Increasing discharge caused the total irrigation water decreased for all treatments because of the time decreased by increasing the discharge.

Total saved water by using lining canal was 19 % that obtained from the previous results are summrized in Table 4.2.

Tabl 4.2 :Total values of saved water using lining canal as a conveyance method were summrized in Table(4.2) .

Discharge, m^3/min	**Saved water. m^3/fed.season**		
	Furrow length, m		
	13	27	40
1	**644.12 (373.12*+271**)**	**646.416 (387.417*+259**)**	**659.95 (397.95*+262**)**
1.5	**551.86 (349.86*+202**)**	**768 (379*+389**)**	**649.179 (391.179*+258**)**
2	**606.896 (337.896*+269**)**	**759.52 (370.52*+389**)**	**736.631 (386.631*+350**)**

*Saved water through conveyance canal.m^3/fed.season.

** Saved water through treatments,m^3/fed.season

The analysis of variance in Table 5.5 in the Appendix Indicated that, the irrigation system, furrow length and discharge had a highly significant effect on the amount of irrigation water per feddan.

4.2. Water use efficiency:

Data presented in Table 4.2 . and illustrated in Figure 4.2 show that the lining canal recorded highly crop yield compared to unlining canal because lining canal used less amount of water than unlining canal and crop yield under lining canal increased. Water use efficiency increased by 13.57% in case of unlining compared to lining canal.

Table 4.3: Effect of discharge, canal type and furrow length on water use efficiency, kg/m$^{3.}$

Canal type	Discharge, m^3/min	Water use efficiency, kg/m^3		
		Furrow length, m		
		13	27	40
Unlining canal	**1**	1.30	1.04	1.03
	1.5	1.31	1.15	1.14
	2	1.33	1.26	1.24
Lining canal	**1**	1.26	1.25	1.24
	1.5	1.39	1.38	1.37
	2	1.58	1.54	1.52

The highest value of water use efficiency was 1.58 kg/m^3 for unlining canal 13 m furrow length and 2 m^3/min water discharge. The lowest value was 1.03 kg/m^3 for 1 m^3 discharge and 40 m furrow length.

Increasing furrow length tended to decrease water use efficiency for lining and unlining canals because a mount of applied water increased. But increasing water discharge tended to increase water use efficiency under lining and unlining canals because a mount of applied water decreased.

The statistical analysis showed that, the irrigation methods, furrow length and water discharge and their interaction had a highly significant effect on water use efficiency as shown in Table 5.1 in the Appendix.

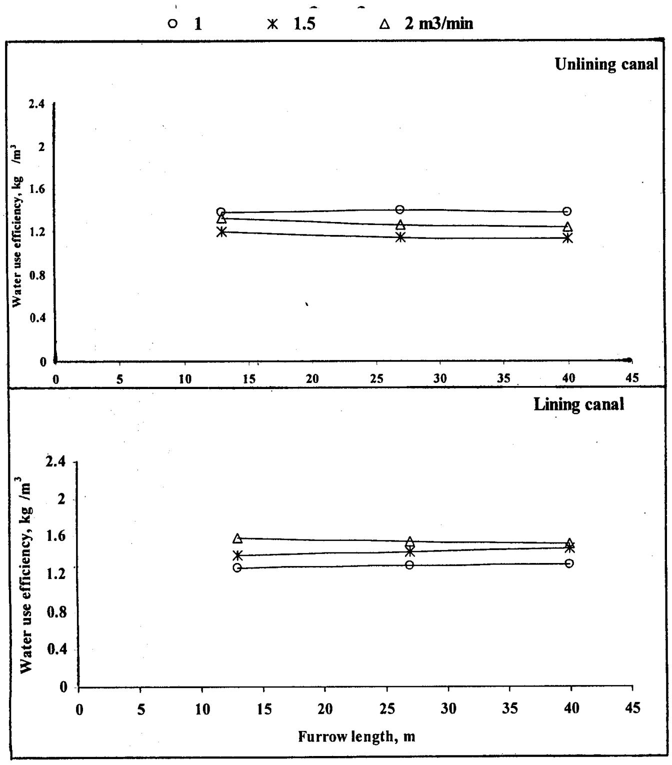


Fig. 4.2 : Effect of discharge, canal type and furrow length on water use efficiency, kg/m^3

4.3. Leaf area index:

Leaf area at 60 days from sowing and leaf area index were presented in Table 4.3 the effect of irrigation method furrow length and water discharge on leaf area were showed in Fig 4.3.

The results indicated that leaf area index was increased by lining canal compared to unlining canal because lining canal increased leaf area index of about 10% compared with the unlining canal irrigation method, where the leaf area index for lining canal irrigation method was 2.87.

Table 4.4: Effect of discharge, canal type and furrow length on leaf area index:-

Canal type	**Discharge, m^3/min**	**Leaf area index**		
		Furrow length, m		
		13	**27**	**40**
Unlining canal	**1**	1.9	2.11	2.45
	1.5	2.32	2.6	2.8
	2	2.95	3.15	3.24
Lining canal	**1**	2.03	2.17	2.83
	1.5	2.53	2.71	3.07
	2	3.28	3.53	3.67

The highest leaf area index was for canal-lining irrigation, 40 m furrow length and 2 m^3/min water discharge. The worst leaf area index was 1.9 for unlining canal irrigation, 13 m furrow length and 1 m^3/min water discharge.

Increasing the furrow length tended to increase leaf area index for unlining canal and lining canal irrigation method and increasing water discharge tended to increase leaf area index under different irrigation method where deficit depth

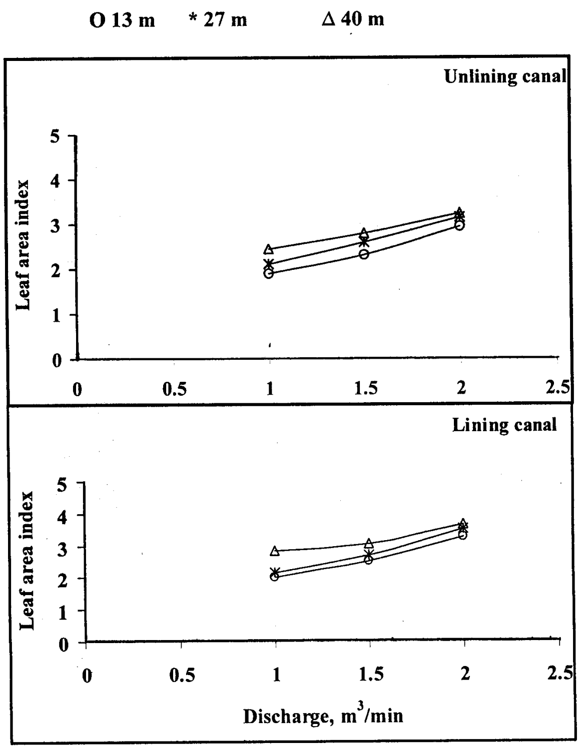


Fig 4.3 : Effect of discharge, canal type and furrow length on leaf area index.

infiltrated at the end of the furrow decreased the furrow length and water discharge had the same effect on leaf area.

The statistical analysis showed that, the irrigation method, furrow length and water discharge and their interactions had a highly significant effect on leaf area and leaf area index as shown in Table 5.4 in the Appendix.

4.4. Root volume:

Corn root volume for different irrigation methods are presented in Table 4.5 and Fig . 4.4 . The results indicated that, lining canal irrigation method increased root volume by 28.29 as compared with earth canal method, . Where aeration under lining canal irrigation method than earth canal irrigation method was best.

Table 4.5: Effect of discharge, canal type and furrow length on root volume, cm^3

Canal type	Discharge, m^3/min	Root volume, cm^3		
		Furrow length, m		
		13	27	40
Unlining canal	1	450	520	573
	1.5	407	470	528
	2	380	411	434
Lining canal	1	671	704	734
	1.5	533	603	660
	2	447	492	538

The highest value of root volume was 734.33 cm^3 for lining canal method, 40 m furrow length and 1 m^3/min water discharge, while the minimum value of root volume was 380 cm^3 for earth canal method, 13 m furrow length and 2 m^3/min water discharge lining canal and unlining canal methods, where the a mount of irrigation water increased. Increasing water discharge tended to increase root volume under lining canal and unlining canal methods.

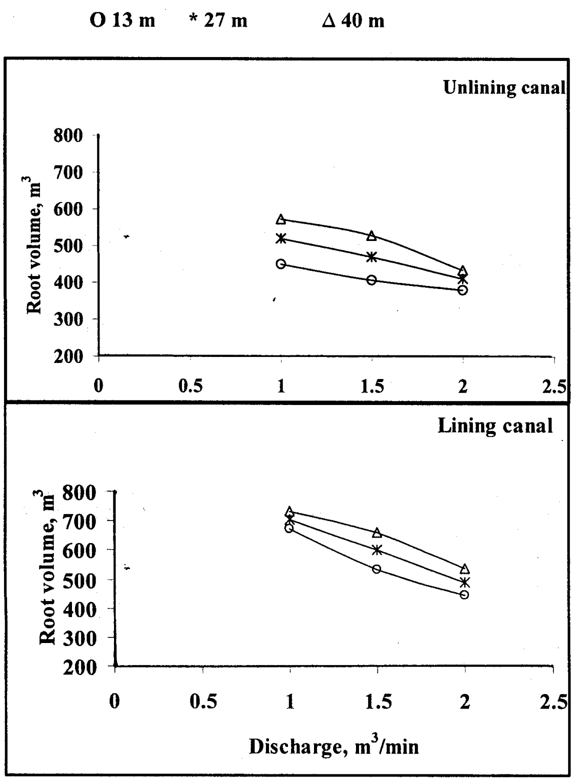


Fig 4.4 : Effect of discharge, canal type and furrow length on root volume

The statistical analysis showed that, the irrigation method, furrow length and water discharge and their interactions had a highly significant effect on root volume as shown in Table (5.3) in the Appendix.

4.5. Corn yield:

Data presented in table 4.6 and illustrated in Fig . 4.5 the results indicated that canal lining method increased grain yield 7.92% compared with unlining canal method. Where the grain yield for lining canal was 3357.44 kg/fed.

Table 4.6: Effect of discharge, canal type and furrow length on grain yield, kg/fed

Canal type	Discharge, m^3/min	Corn yield kg/ fed		
		Furrow length, m		
		13	27	40
Unlining canal	1	2973	3112	3251
	1.5	3270	3362	3436
	2	3510	3594	3709
Lining canal	1	3276	3437	3656
	1.5	3480	3625	3780
	2	3690	3800	3867

The high production of corn under lining canal irrigation may be attributed to the improvement of soil conditions. The highest grain yield was 3867 kg/fed lining canal method, 40 m furrow length and 2 m^3/min water discharge, while the worst grain yield was 2973 kg/fed for unliningcanal method, 13m furrow length and 1 m^3/min water discharge.

Increasing furrow length tended to increase grain yield under different irrigation methods.

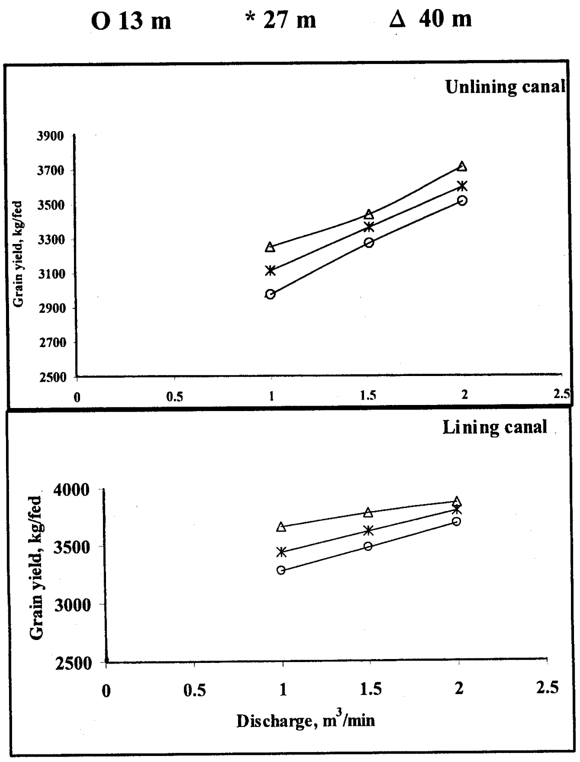


Fig 4. 5 : Effect of discharge, canal type and furrow length on grain yield, kg/fed

The results indicated that grain yield increased by increasing water discharge under different irrigation methods, where the deficit depth at the end of the furrow decreased.

The statistical analysis showed that, the irrigation method, furrow length and water discharge and their interactions had a highly significant effect on grain yield as shown in Table .5.2 in the Appendix.

4.6. Conveyance effieciency :

Conveyance effieciency (C.E) that obtaned from the previous results are summrized in Ttable 4.7 as follows :-

Discharge m^3/min	C.E %		**Mean**
	Lining canal	**Unlining Canal**	
1	**94.63**	**81**	**87.82**
1.5	**94.96**	**82**	**88.48**
2	**95.92**	**83**	**89.48**
Mean	**94.96**	**82**	

From Ttable (4.7). conveyance effieciency for lining canal was 95 % aproxmatly and 82 % for earth canal. Losses from lining canal because evaporation and percolation from gated. Losses from earth canal because evaporation, seepage and leakag . Low velocity caused increasing seepage and evaporation.

Velocity (v) that obtained from results showed in table (4.8), as follow :-

Discharge m^3**/min**	**Velocity (v) m/ see**		**Mean**
	Lining canal	**Unlining Canal**	
1	**0.2**	**0.078**	**0.139**
1.5	**0.347**	**0.1176**	**0.232**
2	**0.52**	**0.156**	**0.338**
Mean	**0.355**	**0.116**	

From Table 4.8, the velocity of water in lining canal was higher than that in unlining canal. These resultes agrement with Hansen et al . (1979).

Infiltration rate

The values of infiltration rate were recorded and listed in the following Table 4.9.

Table 4.9. Infiltration rate (mm/h) and cumulative infiltration depth mm

Elapsed time, minutes	**Infiltration rate, mm/h**	**Cumulative infiltration depth, mm**
0	0.0	0.0
5	73.0	7.0
10	49	11.0
20	31	16.0
30	25	20.0
45	13	23.0
60	9.0	25.0
90	7.0	28.0
120	7.0	31.0
180	7.0	37.0

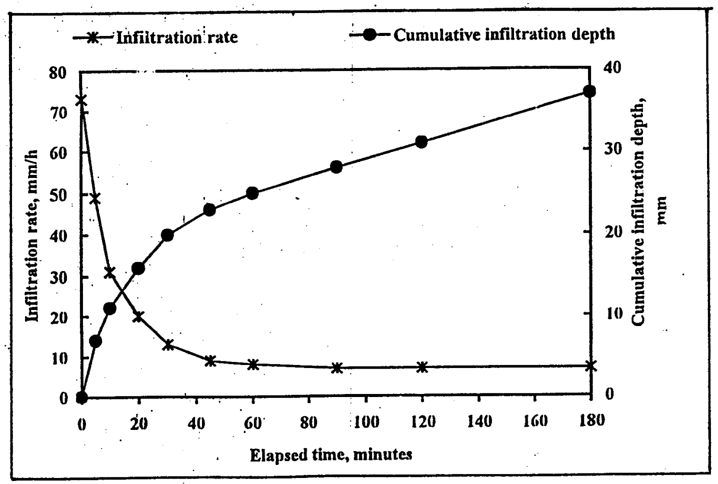


Fig. 4.6. Effect elapsed time by minutes on infiltration rate (mm/h) and cumulative infiltration depth mm

Summary and Conclusion

The present work was carried out at El-Karada station, Kafr El-Sheikh Govemorate during Summer season of 2003. Table 3-1 indicates the mechanical analysis of the soil and the soil texture which was clayey,

The experimental treatments were arranged in split-split plot design with three replicates as shown in Fig. 3.1. The main plot was assigned as two irrigation methods (irrigation through earth canal and irrigation through lining canal). The sub plot treatments were the furrow length 13, 27 and 40 m respectively.The sub-sub plot treatments were three different values of irrigation water discharge(1.5 and 2 m3/min).

The parameters for different treatments were calculated as follows :-

1-Amount of applied water to each treatment

2-Root volume.

3-Leaf area index.

4-Corn yield.

5- Water use efficiency

6-Conveyance effieciency

- According to the obtained results, it may be concluded that;

1-Applied irrigation water,

a-The lining canal irrigation method saved water about 19% compared with unlining carmal.

b-Increasing furrow' length tended to increase the amount of water for unlining canal and lining canal irrigation method, c- Increasing discharge caused the total irrigation water decreased for all treatments.

d- The least amount of water for unlining canal was 2600 m^3/ fed at 13 m furrow length and $2m^3$/ min dicharg but to lining cannal 2331 m^3 / fed at 13 m furrow length and 2 m^3 / min dicharg

e-The highest amount was used by unlining canal was 3062 m^3 / min at 40 m furrow length and dicharge $1m^3$ / min but by used cannal lining highest amount was 2800 m^3/min at 40 m furrow length

and dicharge 1 m^3/min

2-Root volume:

a-The lining canal irrigation method increased root volume by 28.29% as compared with unlining canal method,

b-The highest value of root volume was 734.33 cm^3 for canal lining method,40 m furrow length and 1m3/min water discharge, while the worst value of root volume was 380 cm^3 for unlining canal method, 13 m furrow length and 2 m^3/min water discharg.

3-leaf area index :

a-canal-lining method increased leaf area index of about 10% compared withthe earth canal irrigation method

b- Increase the farrow length tended to increase leaf area index for earthcanal and canal lining Irrigation method

c-increase water discharge tended to increase leaf area index under different irrigation method

d- The highest leaf area index was for canal-lining irrigation, 40 m furrow length and 2 m^3/mm water discharge. The worst leaf area index was 1,9 for earth canal irrigation, 13 m furrow length and $1m^3$/mm water discharge.

4-corn yield:

a-Canal- lining method increased corn yield by 7.92% compared with earth canal method,

b-Increase furrow length tended to increase corn yield under different irrigation methods.

C-Corn yield increased by increasing water discharge under different irrigation methods

d- The high production of corn under canal- lining irrigation may be attributed to the improvement of soil conditions. The highest corn yield was 3867 kg/fed forcanal- lining method, 40 m furrow length and 2 m^3/min water discharge, while the worst corn yield was 2973 kg/fed for earth canal method, 13m furrow length and 1 m^3/min water discharge.

5-Water use efficiency:

a-. Water use efficiency increased by 13.57% at use lining canal as compared with earth canal

b- Increasing furrow length tended to decrease water use efficiency for canal lining and earth canal method

c- Increasing water discharge tended to increase water use efficiency under canal- lining and earth canal irrigation methods.

d- The highest value of water use efficiency was 1.58 kg/m^3 for earth canal irrigation method, 13 m furrow length and2 m^3/min water discharge. The worst value was 1.03 kg/m^3 for discharge 1m^3/min,40m furrow length.

6-Conveyance effieciency:

a-The conveyance effieciency for lining canal was 95% aproxmatly and 82 % for unlining canal.

b-The velocity of water in lining canal was higher than that in unlining canal c-The lining canal saved water in canal through conveyance by13% and total saved water by 19%

***Applied recommendations:**

1-'It is recommended to use cannal linirig method nrigation where it saved water by 19% under condition of experiment.

2-Under condition of experiment,it is recommended to use 13m furrow length and 2 m^3/min dicharge to obtain highest use efficiency ,

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Table (5.1) Analysis of variance for water efficiency

S.O.V.	D.F	M.S
Reps (R)	2	0.0309
Type of canal (T)	1	0.5953
Error (a)	2	0.0018
Row length (L)	2	0.0386 ns
T x L	2	0.02205 ns
Error (b)	8	0.0110
Discharge	2	0.1988**
T x D	2	0.0138 ns
L x D	4	0.00689 ns
T x L x D	4	0.0109 ns
Error (c)	24	0.0053
Total	53	

CV (b) = 8.1 % ; CV (c) = 5.7 %

** = significant at 1% level;
* = significant at 5 % level;
ns = not significant

Table (5.2) Analysis of variance for yield / fed.

S.O.V.	D.F	M.S
Reps (R)	2	7455.5
Type of canal (T)	1	800810.666
Error (a)	2	9516.055
Row length (L)	2	362721.16 ns
T x L	2	1522.166 <1
Error (b)	8	93436.194
Discharge	2	766108.166**
T x D	2	34980.166 <1
L x D	4	11740.166 <1
T x L x D	4	4534.666 <1
Error (c)	24	54605.222
Total	53	

CV (b) = 8.7 % ; CV (c) = 6.7 %

** = significant at 1% level;
 * = significant at 5 % level;
ns = not significant

Table (5.3) Analysis of variance for root volume.

S.O.V.	D.F	M.S
Reps (R)	2	1417.12962
Type of canal (T)	1	244016.66
Error (a)	2	84.388
Row length (L)	2	42269.796**
T x L	2	42.722<1
Error (b)	8	3973.537
Discharge	2	113540.07**
T x D	2	12489.55 ns
L x D	4	1021.7407 <1
T x L x D	4	905.111 <1
Error (c)	24	6634.833
Total	53	

CV (b) = 11.9 % ; CV (c) = 15.3 %

** = significant at 1% level;
* = significant at 5 % level;
ns = not significant

Table (5.4) Analysis of variance for leaf area index.

S.O.V.	D.F	M.S
Reps (R)	2	0.00857
Type of canal (T)	1	0.8816
Error (a)	2	0.0104
Row length (L)	2	1.1745**
T x L	2	0.0386 ns
Error (b)	8	0.0129
Discharge	2	5.0737**
T x D	2	0.05231 ns
L x D	4	0.06629 ns
T x L x D	4	0.00869 <1
Error (c)	24	0.02592
Total	53	

CV (b) = 4.1 % ; CV (c) = 5.9 %

** = significant at 1% level;
 * = significant at 5 % level;
ns = not significant

Table (5.5) Analysis of variance for applied water

S.O.V.	D.F	M.S
Reps (R)	2	48.38
Type of canal (T)	1	1166886.00
Error (a)	2	18.055
Row length (L)	2	338328.00**
T x L	2	11048.00**
Error (b)	8	12.555
Discharge	2	177718.500**
T x D	2	6399.500**
L x D	4	8528.25**
T x L x D	4	4342.75**
Error (c)	24	11.6944
Total	53	

CV (b) = 0.1 % ; CV (c) = 0.1 %

** = significant at 1% level;
* = significant at 5 % level;
ns = not significant

الملخص العربي

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يستخدم الري السطحي منذ ٦٠٠٠عاما قبل الميلاد لذا يعتبر الري السطحي من أقدم طرق لري استخداما وتضاف المياه عن طريق الأحواض أو الشرائح أو الخطوط ومن مميزات استخدام الري بالخطوط :-

١ ـ أنه يوفر كمية كبيرة من المياه لأن جزء من الأرض لا يكون مبتلا .
٢ـ يقلل من نمو الحشائش ويسهل القيام بعمليات الخدم مع قلة فقد المحصول .
٣ـ يساعد على توزيع أفضل للماء .

* وعموما فأن كفاءة الري هى دالة لمجموعة من الكفاءات مثل كفاءة الاستخدام المائي وكفاءة النقل وكفاءة التوزيع . لذلك أي زيادة في هذه الكفاءات تؤدي إلى زيادة كفاءة الري السطحية فتماثل إضافة المياه وتنقص الفاقد بالتسرب العميق والرشح الجانبي بالتصميم الجيد لأنظمة نقل وتوزيع المياه .

* أجريت التجربة بمحطة القرضا ـ بمحافظة كفر الشيخ ، بهدف رفع كفاءة الري وكانت مساحة القطعة التجريبية ٣٧م × ٨٠ م .

الهدف من الدراسة

١ ـ تحسين كفاءة الري
٢ـ توفير الفقد فى مياه الري

المتغيرات الرئيسية

١ـ نوع القناة :-
ا- قناة غير مبطنة   ب- قناة مبطنة

٢ـ التصرف
* ثلاث تصرفات (١م^{٣} / دقيقة ، ١,٥ م^{٣} / دقيقة ، ٢م^{٣} / دقيقة)

٣ـ طول الخط
* ثلاثة أطوال (١٣ ، ٢٧ ، ٤٠ م)

وكانت النتائج كالتالي :

كمية المياه المضافة:

ا- اظهرت النتائج ان هناك علاقة طرديه بين كميه المياه المضافة وطول الخط , وان هناك علاقة عكسية بينهما والتصرف وذلك لنقص زمن الري وهذا لكل من القنوات المبطنة وغير المبطنة.
ب- أظهرت النتائج إن الري بالقنوات المبطنة يوفر كمية مياه الري بنسبة ١٩٪ للفدان بالمقارنة بالري بالقنوات غير المبطنة.
ج- ا قل كمية مياه (٢٣٣١ م٣ / ف) كانت عند استخدام القنوات المبطنة و طول خط ١٣م و تصرف ٢ م٣/ د .
د- اكبر كمية مياه كانت(٣٠٦٢م٣/ف) عند استخدام القنوات الغير مبطنه وطول خط ٤٠م وتصرف ١م٣ .

٢-دليل مساحة الورقة:

ا- زادت نسبة دليل المساحة الورقية بنسبة ١٠٪ في الري بالقنوات المبطنة مقارنة بالري بالقنوات الترابية وكانت اعلي قيمة ٣,٦٧ عند طول خط ٤٠م وتحت تصرف ٢م^{٣} / د وذلك بنظام القنوات المبطنة.

ب- وجد إن اقل قيمة ١,٩ تحت نظام الري بالقنوات الغير مبطنه عند استخدام طول خط ١٣م وتصرف ١م^{٣} / د.

ج- اد ت زيادة طول الخط إلى زيادة دليل مساحة الورقة حيث تقل منطقة الجذور الغير مشبعة في نهاية الخط بالنسبة لطريقتي الري المستخدمتين.

د- وجد من الدراسة ان هناك علا قه طرديه بين نسبة المساحة الو رقية والتصرف.

٣ -حجم الجذر:

ا- لوحظ زيادة حجم الجذر بنسبة ٢٨,٢٩ ٪ باستخدام طريقة الري القنوات المبطنة مقارنة بالقنوات الترابية وذلك لظروف التهوية الجيدة.

ب- كانت اعلي قيمة لحجم الجذر (٧٣٤,٣ سم^{٣}) ، وذلك عند استخدام الري بالقنوات المبطنة و طول خط ٤٠م وتصرف ١م^{٣} / د بينما كانت اقل قيمة(٣٨٠سم٣)عند الري بالقنوات الترابية عند طول خط ١٣م وتصرف ٢م^{٣} / د.

ج- أدت زيادة طول الخط إلى قلت حجم الجذر لكل من طريقتي الري بالقنوات المبطنة والترابية بسبب زيادة كمية مياه الري.

د- وجد من الدراسة أن هناك علاقة طرديه بين التصرف و حجم الجذر بالنسبة لكلتا طريقتي الري.

٤ -الإنتاجية:

ا- أظهرت النتائج إن طريقة الري بالقنوات المبطنة تزيد الإنتاجية بنسبة ٧,٩٢٪ مقارنة بالطريقة الأخرى وكان إنتاج محصول الفدان ٣,٣٥٧٤٤ ميجا جرام باستخدام القنوات المبطنة.

ب- وكانت اعلي إنتاجية(٣,٨٦٧ميجاجرام / ف)عند استخدام طول خط ٤٠م وتصرف ٢م^{٣} / د القنوات المبطنة.

ج- كانت اقل إنتاجية (٢,٩٧٣ ميجا جرام / ف) بطريقة الري بالقنوات الغير مبطنه عند طول خط ١٣م وتصرف ١م٣ / د.

د - أدت زيادة طول الخط إلى زيادة الإنتاجية لكل من الري بالقنوات المبطنة الغير مبطنه.

هـ - وجد من الدراسة انه بزيادة التصرف يزداد الإنتاج.

٥- كفاءة استخدام مياه الري:

ا- أوضحت النتائج زيادة كفاءة استخدام مياه الري باستخدام القنوات المبطنة بنسبة ١٣,٥٧٪ مقارنة بالري بالقنوات الغير مبطنة.

ب- كانت اعلي كفاءة استخدام (١,٥٨ كج / م٣) وذلك بطريقة القنوات

المبطنة عند طول خط ١٣م وتحت تصرف ٢م^{٣} / د وكانت اقل قيمة (١,٠٤ كج/ م^{٣}) عند استخدام القنوات الغير مبطنه عند طول خط ٤٠م و تصرف ١ م^{٣} / د.

ج- أدت زيادة طول الخط إلى قلة كفاءة الاستخدام وذلك لطريقتي الري لأن كمية المياه تزداد بزيادة طول الخط.

د- أدت زيادة التصرف إلى زيادة كفاءة الاستخدام لطريقتي الري لأن كمية المياه تقل.

٦- كفاءة التوصيل للقناه

ا- كانت كفاءة التوصيل للقناة المبطنة ٩٥٪ تقريبا بينما كانت ٨٢٪ للقناه الغير مبطنه

ب- كانت سرعة المياه في القناة المبطنة أكبر منها فى الغير مبطنه

ج- أدت زيادة التصرف إلى زيادة سرعة المياه في القناة وزيادة كفاءة التوصيل وذلك للقنوات المبطنة والغير مبطنه

د- وفرت القنوات المبطنة مياه الري بنسبه١٩٪

التـ..وصيـ.......ات التطبيقيه :-

١- يوصى باستخدام طريقة الري بالقنوات المبطنة حيث أنها وفرت ١٩٪ من كمية مياه الري تحت ظروف التجربة .

٢- عند استخدام متغيرات التجربة يوصى باستخدام طول خط ١٣م وتصرف ٢م^{٣} / دقيقة حيث أنهما أعطيا أفضل كفاءة استخدام بالنسبة للطريقتين .

مستخلص عربي

موضوع الرسالة / دراسة على تطوير طريقة الري بمنطقة الدلتا

عنوان الرسالة / دراسة على تطوير طريقة الري بمنطقة الدلتا

مقدمة من الطالب / عزة عبد السلام محمد الهنداوي

الهدف من البحث / توفير كمية مياه الري

- أجريت التجربة في محطة القرضا – محافظة كفر الشيخ ، أثناء موسم صيف ٢٠٠٣ ، وذلك لدراسة تأثير كلا من طريقة الري بالقنوات المبطنة والقنوات الغير مبطنة وثلاثة أطوال خطوط (١٣ ، ٢٧ ، ٤٠ م) ، وثلاث تصرفات (١ ، ١,٥ ، ٢م^{٢} / دقيقة) على كل من الصفات الآتية :

١- كمية المياه المضافة .
٢- الإنتاجية .
٣- حجم الجذر .
٤- دليل مساحة الورقة .
٥-كفاءة الاستخدام بمياه الري
٦- كفاءة التوصيل

وكانت النتائج كالتالي :

١ -كمية المياه المضافة :

كانت أقل كمية مياه ، (٢٣٣١م^{٢}/دقيقة) بالري في القنوات المبطنة عند طول خط ١٣م وتصرف٢م٣/دقيقة بينما كانت أكبر كمية مياه مضافة (٣٠٦٢ م^{٣}/دقيقة) باستخدام القنوات الغير مبطنة وتحت تصرف ١م^{٣} / دقيقة وطول خط٤٠م. وفرت طريقة الري بالقنوات المبطنة مياه الري بنسبة ١٩٪ مقارنة بطريقة الري بالقنوات الغير مبطنة .

٢-الإنتاجية :

كانت أعلى إنتاجية (٣٨٦٧ كجم / فدان) وذلك باستخدام القنوات المبطنة تحت تصرف ٢ م^{٣} / دقيقة ، و طول خط ٤٠م بينما كانت أقل قيمة (٢٩٧٣ كجم / فدان) تحت تصرف ١م^{٣} / دقيقة وعند طول خط ١٣ م وذلك باستخدام القنوات الغير مبطنة .

٣-حجم الجذر :

كانت أعلى قيمة ٧٣٤ سم^{٣} وذلك باستخدام القنوات المبطنة عند طول خط ٤٠م وتصرف ١ م٣ / دقيقة بينما كانت أقل قيمة ٣٢٠سم^{٣} وذلك باستخدام القنوات الغير مبطنة عند طول خط ٢٧ م وتصرف ١م^{٣} / دقيقة .

٤-دليل مساحة الورقة :

كانت أعلى قيمة (٣,٦٧) وذلك باستخدام القنوات المبطنة عند طول خط ٤٠ م وتصرف م^{٣} / دقيقة بينما كانت أقل قيمة (١,٩) وذلك باستخدام القنوات الغير مبطنة عند طول خط ١٣م وتصرف ١م^{٣} / دقيقة .

٥-كفاءة الاستخدام :

كانت أعلى قيمة (١,٥٨) وذلك باستخدام القنوات المبطنة عند طول خط ١٣ وتصرف ٢م^{٣} / دقيقة ، بينما كانت أقل قيمة (١,٠٣) وذلك باستخدام القنوات الغير مبطنة عند طول خط ٤٠ م وتصرف ١م^{٣} .

٦- كفاءة التوصيل :

كانت كفاءة التوصيل للقنوات المبطنة حوالي ٩٥٪ بينما كانت ٨٢٪ للقنوات الغير مبطنة
كانت سرعة المياه في القنوات المبطنة أكبر منها في القنوات الغير مبطنة .

لجنة الإشراف

الأستاذ الدكتور

ممدوح عباس حلمى

أستاذ الهندسة الزراعية
ورئيس مجلس قسم الميكنة الزراعية
كلية الزراعة بكفر الشيخ – جامعة طنطا

دكتور

محمد لطفى نصر

رئيس بحوث
ووكيل معهد بحوث إدارة المياة- القناطر- مصر

دكتور

السعيد محمد أحمد خليفة

أستاذ الهندسة الزراعية المساعد
كلية الزراعة بكفر الشيخ – جامعة طنطا

٢٠٠٥

"دراسة علي تطوير طريقة الري بمنطقة الدلتا"

رسالة مقدمة من

عزة عبد السلام محمد الهنداوي

للحصول علي درجة الماجستير في العلوم الزراعية (الميكنة الزراعية)

لجنة المناقشة والحكم علي الرسالة:

الأستاذ الدكتور/ **محمود عبد العزيز حسن**.................................
أستاذ الهندسة الزراعية - قسم الهندسة الزراعية
كلية الزراعة – جامعة الزقازيق

الأستاذ الدكتور/ **ممدوح عباس حلمي**.................................
أستاذ الهندسة الزراعية ورئيس قسم الميكنة الزراعية
كلية الزراعة بكفر الشيخ - جامعة طنطا

الأستاذ الدكتور/ **إسماعيل أحمد عبد المطلب**.................................
أستاذ الهندسة الزراعية – قسم الميكنة الزراعية
كلية الزراعة بكفر الشيخ - جامعة طنطا

الدكتور/ **السعيد محمد أحمد خليفة**.................................
أستاذ الهندسة الزراعية المساعد – قسم الميكنة الزراعية
كلية الزراعة بكفر الشيخ - جامعة طنطا

جامعة طنطا
كلية الزراعة بكفر الشيخ
قسم الميكنة الزراعية

عنوان الرسالة:

دراسة على تطوير طريقة الري بمنطقة الدلتا

رسالة مقدمه من

عزة عبد السلام محمد الهنداوى

بكالوريوس علوم زراعية (ميكنة زراعية)، كلية الزراعة بكفر الشيخ ـ جامعة طنطا ١٩٩١

للحصول على درجة
الماجستير فى العلوم الزراعية
(ميكنة زراعية)

قسم الميكنة الزراعية
كلية الزراعة بكفر الشيخ
جامعة طنطا

٢٠٠٥