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ASSESSMENT OF SURFACE AND SUBSURFACE DRIP IRRIGATION SYSTEMS WITH DIFFERENT SLOPES BY HYDROCALC MODEL

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ABSTRACT: The HydroCalc simulation model is considered one of the designs, planning and evaluating the hydraulic parameters of irrigation systems, and using this model added more advantages to the measurements of hydraulic evaluations of irrigation system. Field trials were conducted in the research farm and production center of the National Research Centre at El-Nubaria, El-Behaira Governorate, Egypt. In the field of irrigation system management, in the drip irrigation, automatic system, the use of sensors installed in the soil determines the water needs. So as to adjust the water added amounts depending on the timetable for the process of irrigation field, which varies from one crop to another. The results could be summarized as follows: using a lateral line length of 60 meters, the friction loss values expected and calculated which were estimated under drip surface and subsurface irrigation systems; subsurface was greater than the surface drip irrigation. The correlation coefficient between the values of the compressor losses due to friction were greater than 0.9. This shows a strong correlation between the predicted values, which were estimated. Significant differences were found between the treatments and the interactions between irrigation systems. The HydroCalc simulation model is recommended for evaluating the subsurface irrigation systems.

Keywords: Hydro-Calc, Automation, Controller, Different slopes, Drip, Irrigation.

1. INTRODUCTION

The automatic control system of drip irrigation using electric automatic valves to start and stop the process of field irrigation. These valves are easily operated automatically by using the controllers which in turn are connected to sensors inside the soil. Automatically control irrigation for farm or nursery, allow farmers to add the appropriate amount of water at the right time and this is called good management for irrigation systems, one irrigation method that reduces the use of water, fertilizer, by adding water slowly either on the soil surface in case of drip surface or area roots directly, as in the case of drip subsurface, [1]. Consequently, the water application rate is one key factor determining the soil, water content around the emitter [2-17]. Water to be added at the ground on a daily basis to maintain a fixed percentage of moisture in order to prevent strain. Optimizing conditions for the plant to carry out construction of photosynthesis complete in the presence of nutrients and optimal use of water in the root zone as in Figure 1, (A and B.). Surface and subsurface drip irrigation water and maintains a provision in zone of plant roots. It requires the use of drip irrigation system, surface and subsurface nearly half of the water used by irrigation sprinkler or surface irrigation quantity. And it requires low operating pressures ranging from 0.7 to 1.5 bars, unlike spray irrigation, which requires pressure run between 3.0- 5.0 bar, [2-4].

A. Subsurface drip irrigation system

B. Surface drip irrigation system

Fig.1 Subsurface and surface drip irrigation in the field.

It's a high degree of control over the amount of water added, because the lack of water added less than the amount calculated by the equations of ETc, and climate data [18, 19, 20; 21]. The objectives of this research work are to investigate the use of HydroCalc simulation models and automated controllers for evaluation subsurface and surface drip irrigation systems in different land topography.

2. MATERIALS AND METHODS

Field experiments were conducted at the experimental farm of National Research Centre, El-Nubaria, Elbuhaira, Egypt. The design of field experiments was split in randomized complete block design with four replicates. The field tests carried out using line length 60m and the following two drip irrigation designs: a) subsurface drip irrigation system (SSDI) and b) surface drip irrigation system (SDI) Fig. 2. And Table (1) indicated there some physical characteristics of there the location and irrigation water, respectively.

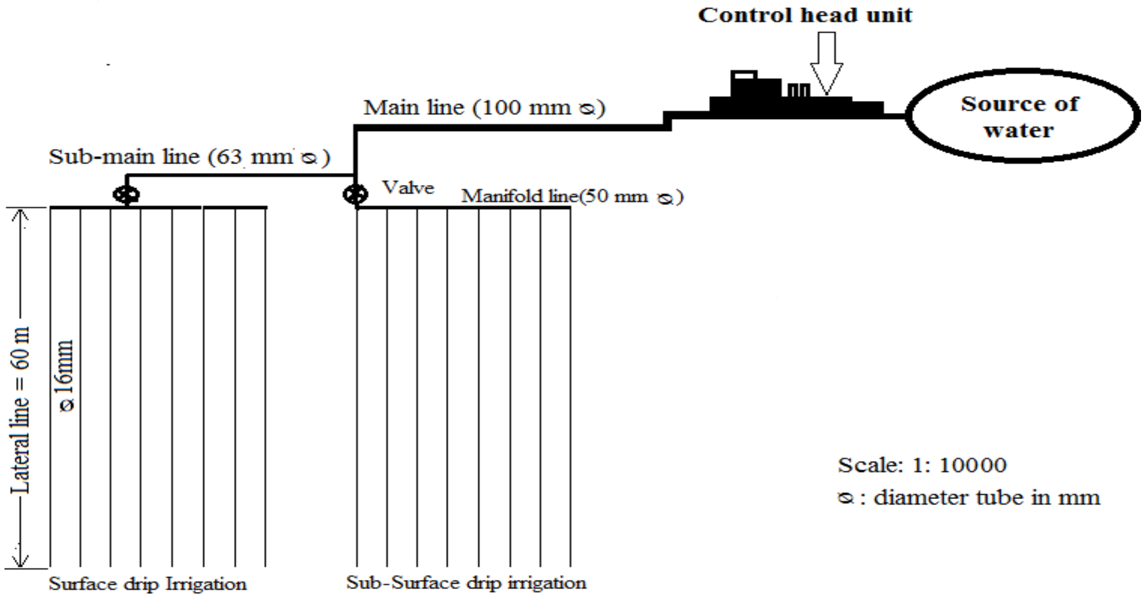

Fig.2 Layout of drip surface and subsurface with two manifolds (SSDI) for lateral lines.

Table 1 Some physical properties of the soil

Sampledepth, cm	Particle Size Distribution, %			θw (w/w)			CaCo3 (%)	O.M. (%)	pH (1:2.5)	EC (dSm-1)	Texture class
	Coarse Sand	Fine Sand	Clay; Silt	F.C.	W.P.	S.P.					
0-20	47.76	49.75	2.49	10.1	4.7	21.0	7.02	0.65	8.7	0.35	Sandy

F.C: Field capacity, W.P.: Wilting point, S.P.: Soil porosity, O.M: Organic matter.

Particle Size Distribution according [22], Moisture retention, according [23], and C.L.: Clay Loam F.C.: Field Capacity, W.P.: Wilting Point, AW: Available Water according [24]. Irrigation networks components and the design of the automation controller based subsurface and surface drip irrigation systems presented by [1-4].

The components of automatic drip irrigation systems are as follows: A) Control Head Station, B) Flow Meter, C) Control, flushing Valves, Chemical Injection Unit (Fertigation unit), Manifolds and Drip lines with Emitters, automation controller unit sends the signal from the sensor is boosted into the required level by corresponding amplifier stages.

The automated control system components according to [1-4] as shown in Figure (3). HydroCalc irrigation system planning software is designed to help the user to define the parameters of an irrigation system as shown in Figures (4 and 5). The calculations are based on the hydraulic equations of William Hazen and Bernoulli as shown in Table (2).

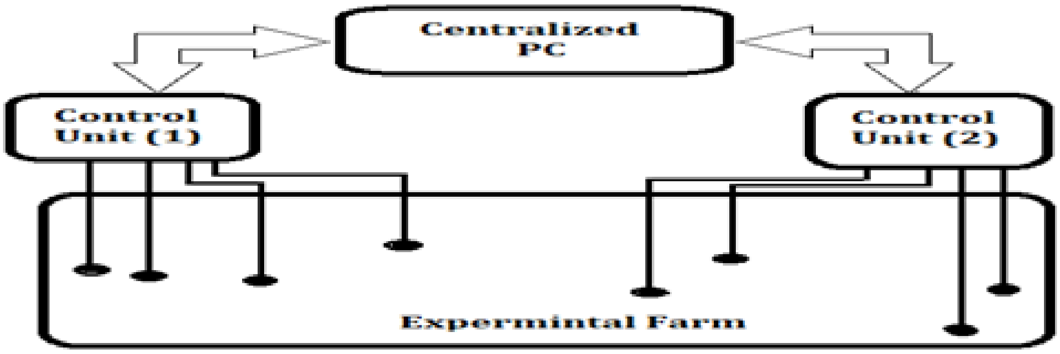

Fig.3 Application of the automation controller unit to field

Fig.4 HydroCalc model for planning irrigation systems.

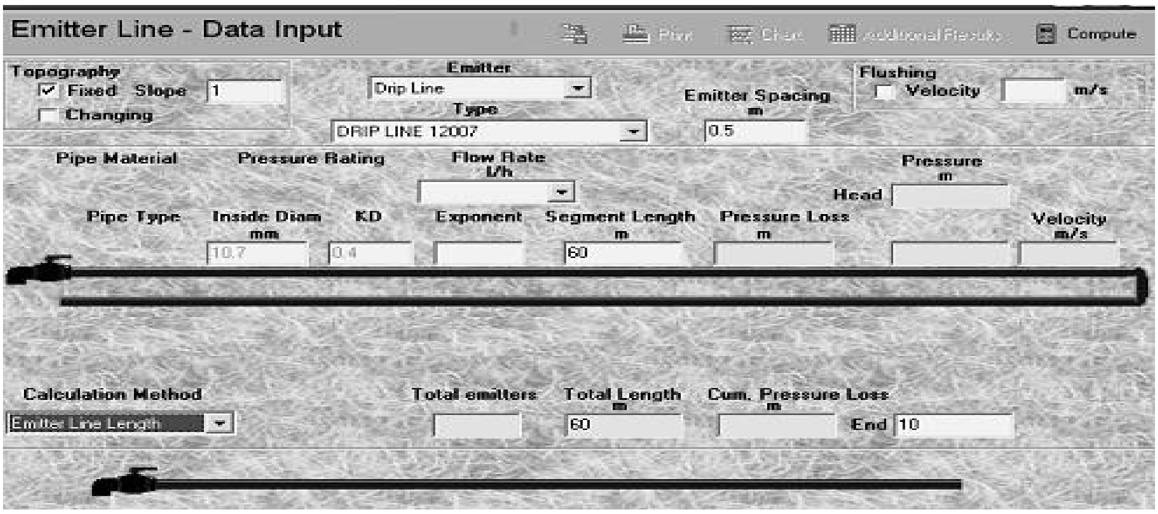

Fig.5 HydroCalc working sheet before computation procedure.

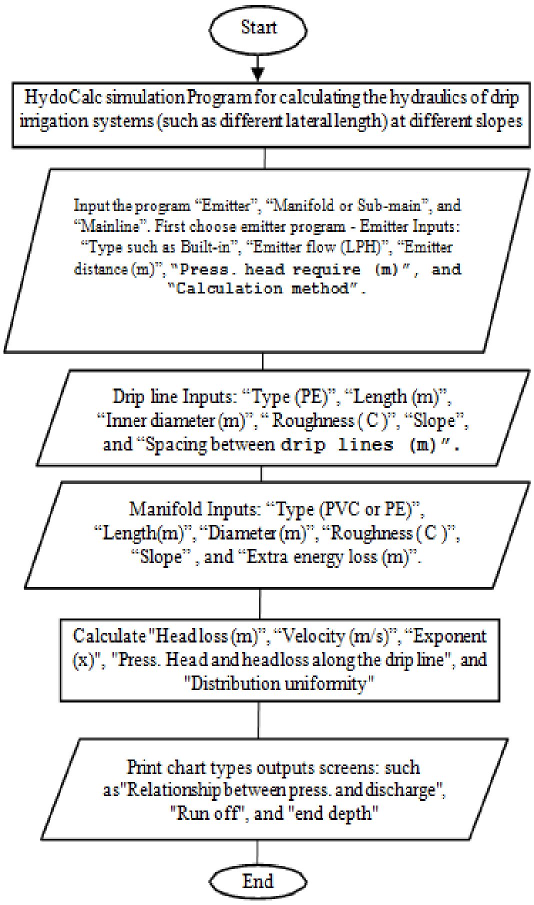

Fig. 6 The inputs, processing, and outputs and all steps in the flow chart of HydoCalc simulation model.

The Emitters program is the first application which can be used in the frame of HydroCalc software program. There are 4 basic types of emitters that can be used: Drip Line, online dripper, Sprinklers, and Micro-Sprinklers. According to the previous selection the user can opt for a specific emitter, which can be a pressure compensated or a non-pressure compensated. Figure (6) shows the inputs, processing, and outputs and all steps in the flow chart of HydoCalc simulation model, according to [25]. The emission from every emitter was calculated using the characteristic equation developed for pressure head vs. discharge for each product.

MSTATC program (Michigan State University) was used to carry out the statistical analysis. Treatment means were compared using the technique of analysis of variance (ANOVA) and the least significant difference (LSD) between systems at 1% had been done according to [26].Use at most three levels of headings that correspond to chapters, sections, and subsections. The first level headings for chapter titles should be in 10pt, bold, justified, and upper case font. Leave one blank line before and after the first level headings, respectively.

3. RESULTS AND DISCUSSIONS

Flow rates and water pressure head were estimated at three points along the lines of emitters (beginning, end and central) for surface and subsurface drip irrigation systems for land slopes 0 and 5%. A Hydro-Calc simulation program to verify the predicted values has been established by Netafim organization-USA as shown in Figures 4 and 5. The calculations are based on the hydraulic equations of William Hazen and Bernoulli as shown in Table (2). The results of forecasting and simulation by the Hydro-Calc program that the value of the exponent (X), and the loss of the water pressure head (m), flow velocity (m/s), and the water pressure head along the lateral line is shown in Table 3 and Figs. 7, 8, 9 and 10.

Table 2 Inputs to the HydroCalc simulation program for surface and subsurface design drip irrigation systems.

Manifold		Drip line		Emitters	
Name	Value	Name	Value	Name	Value
Pipe type:	PVC	Tubes type	PE	Emitter type	Built in
Pipe length	-----	Tube lengths:	60	Emitter flow (Lph)	4
Pipe diameter	0.05 m	Inner diameter	0.0142 m	Emitters distance	0.30 m
(C) Pipe roughness	150	(C) Pipe roughness	150	Press head requires (m)	10.0 m
Slope	0 m/m	Slope	0 or 0.02 m/m	Calculation method	Flow rate variation
Extra energy losses	0.064	Spacing	0.7 m	---	---

Table 3 Predictive exponent (x), Head loss (m) and velocity (m/s) by the HydroCalc simulation program for subsurface and surface drip irrigation design with different slopes (0 and 5%).

	Irrigation connection design					
Field slope, (%)	Exponent (x)	SSDI Head loss (m)	Velocity (m/s)	Exponent (x)	SDI Head loss (m)	Velocity (m/s)
0	0.69	1.03	1.48	0.69	0.64	1.62
	0.62	2.01	1.51	0.61	0.88	1.76
	0.55	3.45	1.87	0.52	1.87	1.91
5	0.87	1.35	1.63	0.86	0.67	1.64
	0.72	1.74	1.76	0.76	1.46	1.87
	0.57	3.47	1.93	0.43	2.68	1.94

The correlation coefficient was significant between the predicted and calculated values for the water pressure head losses along the drip line of surface and subsurface irrigation where the values of correlation analysis were greater than 0.9 in the case of no slope (Slope = 0%).

The analysis of calculated and predicted values in the water pressure head losses along the drip line length of 60 meters for irrigation drip surface and subsurface in the no slope (0 % values as shown in Table (3) and Figs. 8 and 9.

Table 4 Pressure head analysis along the lateral lines in subsurface and surface drip irrigation (SSDI and SDI) when slope 0% level.

Distanc ealong laterals (m)	Drip irrigation circuits			
	SSDI		SDI	
	Predictive	Measured	Predictive	Measured
1	0.96	0.94	0.95	0.92
6	0.95	0.91	0.94	0.90
12	0.94	0.90	0.93	0.88
18	0.93	0.88	0.92	0.88
24	0.92	0.88	0.91	0.87
30	0.91	0.87	0.90	0.86
36	0.90	0.86	0.89	0.86
42	0.89	0.85	0.88	0.85
48	0.88	0.84	0.87	0.85
54	0.87	0.83	0.86	0.84
60	0.86	0.82	0.85	0.83
Average	0.88	0.87	0.859	0.833
LSD0.01	0.01	0.02	0.01	0.01

In Table (4), Data shows the head pressures of water (bar) along the emitter lateral lines of the different SSDI and SDI. Clearly the irrigation subsurface and surface drip systems under study could be ranked in the following ascending order Surface drip irrigation<Subsurface drip irrigation according to the values of the head pressures of water. LSD0.01 values in Table (4) under sub-surface drip irrigation and surface drip irrigation showed there was no significant difference between both start and end values.

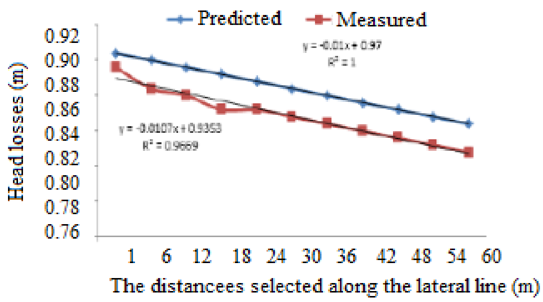

Fig. 7 The relationship between different lateral line length 60 m and both the predictive and measured head losses when the slope was 0% with the SSDI design.

In Table (4), Data shows the head pressures of water (bar) along the emitter lateral lines of the different SSDI and SDI. Clearly the irrigation subsurface and surface drip systems under study could be ranked in the following ascending order Surface drip irrigation<subsurface drip irrigation according to the values of the head pressures of water. LSD0.01 values in Table (4) under sub-surface drip irrigation and surface drip irrigation showed there was no significant difference between both start and end values. The predictive head loss analysis when land sloped by 5% along the lateral line or the emitter line calculated by the HydroCalc simulation model for subsurface and surface drip irrigation systems SSDI and SDI. Fig (7 and 8) and Table (5) showed the relationship between predictive and calculated water pressure head losses as well as the coefficient of correlations.

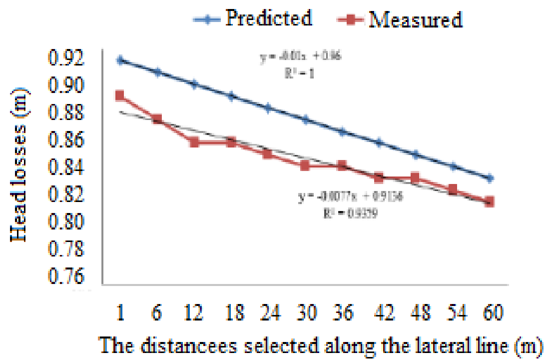

Fig. 8 The relationship between different lateral line lengths (60m) and both the predictive and measured head losses when the slope was 0% with the SDI design.

Irrigation methods under study when using a lateral length 60 m could be ranked in the following ascending order according to the values of the predicted and measured head losses: Surface drip irrigation<sub-surface drip irrigation. The correlation (Corr.) coefficients were used to compare the predictive and measured water pressure head losses along the emitter lateral lines of all the subsurface and surface drip designs. Generally, the values of correlation coefficient analysis were greater than 0.9 obtained with 0% and 5% field slope 60m length for all surface and sub-surface drip systems. These data are supported by references, [3, 6, 7, 18; 21]. Data in Table (5) and Figs. (9 and 10) shows the water head pressures (bar) along the lateral lines of the different surface and sub-surface drip irrigation. When using a lateral length 60 m under surface and sub-surface drip irrigation methods. The interaction between irrigation methods: at the start there are significant differences between surface and sub-surface drip irrigation. While in both of

end and middle values there are significant differences between surface and sub-surface drip irrigation. The data are supported by references, [26- 56].

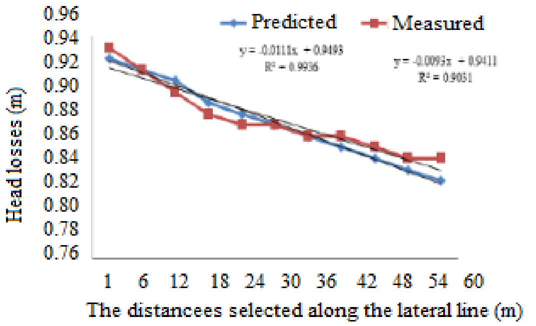

Fig.9 The relationship between different lateral line length 60 m and both the predictive and measured head loss when the land sloped 5% down with the SSDI design.

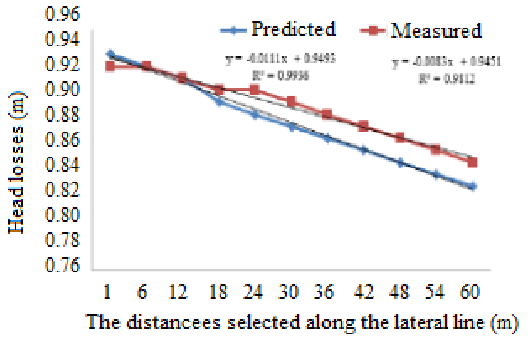

Fig.10 The relationship between different lateral line length 60m and both the predictive and measured head loss when land sloped 5% down with the SDI design.

Table 5 Pressure head analysis along the lateral lines in drip irrigation subsurface and surface SSDI and SDI method when land slopes 5% level.

Distance along laterals (m)	Drip irrigation circuits			
	SSDI		SDI	
	Predictive	Measured	Predictive	Measured
1	0.94	0.95	0.94	0.93
6	0.93	0.93	0.93	0.93
12	0.92	0.91	0.92	0.92
18	0.90	0.89	0.90	0.91
24	0.89	0.88	0.89	0.91
30	0.88	0.88	0.88	0.90
36	0.87	0.87	0.87	0.89
42	0.86	0.87	0.86	0.88
48	0.85	0.86	0.85	0.87
54	0.84	0.85	0.84	0.86
60	0.83	0.85	0.83	0.85
Average	0.88	0.89	0.88	0.89
LSD0.01	0.01	0.01	0.02	0.01

According to the emitter lateral length 60m, the values of the water pressure head under different irrigation systems could be arranged in the following ascending order: surface drip irrigation < sub-surface drip irrigation.

This may be attributed to the decreased the water pressure head loss along the emitter lateral line by using the surface and sub-surface drip irrigation. LSD0.01 values in Table (5) show that under surface and sub-surface drip irrigation there is no significant difference between both start and end values of water pressure head, but there are significant differences between middle and both start and end water pressure head values.

4. CONCLUSIONS

Automatic control of drip irrigation systems helps with real time application which can monitor and control all the activities of subsurface and surface drip irrigation systems and increasing efficiency. Using this system, one can save manpower, water to improve production and ultimately profit.

The data support the following conclusion: surface and sub-surface drip irrigation systems when using a lateral length of 60 m can be ranked in the following ascending order according to the values of the predicted and calculated water pressure head losses surface drip irrigation<subsurface drip irrigation.

The correlation coefficient was used to compare the predicted and measured water head losses along the emitter lateral lines of all subsurface and surface drip irrigation systems. Generally, values of correlation analysis greater than 0.9 were obtained with 0% land slope when emitter lateral line length was equal to 60m.The interactions were significant between surface and sub-surface drip irrigation systems along emitter lines.

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