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EXPERT SYSTEM FOR CHOOSING THE COMPONENTS OF DRIP IRRIGATION SYSTEM HEAD CONTROL UNIT IN THE EGYPTIAN MARKET: VALIDATION PROCESS

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Abstract

The Egyptian market for irrigation systems is very wide, because the importance of it for the cultivation in the new reclaimed land which depends mainly on it. There are numerous models and brands for each component of irrigation system which makes the farmer and/or the designer confused. Furthermore the main component of irrigation system is the head control unit which has an effect on the performance of the whole system and consequently the final production of the water unit. Therefore the main objective of this research work to test the developed expert system for choosing the proper components of the head control unit for drip irrigation network according to the availability in the Egyptian market. This expert system consolidate the scientific research. Technical specifications database had been gathered from the common brands and models of components of the control head. The selection processes based on different criteria, such as water resources and water unit characteristics, irrigated area, crop type, climate and soil texture. The expert system was named TSDICU-ES (Technical Specification of Drip Irrigation-Expert System) was coded and compiled using Microsoft Visual Basic, the program was validated by carrying out a field experiment at the Experimental Farm of Agricultural Production and Research Station (APRS), National Research Centre (NRC), El Nubaria District, El-Behaira Governorate, Egypt. Results indicated that it is possible to use the TSDICU-ES rule-based program and got a very specific and good results for choosing all proper components of control head unit in drip irrigation system and there are a high agreement between the selected components by the TSDICU-ES program and the existed components in the farm by 96%.

***Keywords**:* Expert systems, irrigation network components, technical specifications.

Introduction

Agricultural consumes more than 84 % of the water resources in Egypt resources (El-Beltagy and Abo-Hadeed, 2008). Therefore, Egypt needs to increase the agricultural production using any tool achieving this goal. The development of agriculture in Egypt is mainly in deserts which uses mainly pressurized irrigation systems such as drip irrigation system. It is very hard for farmers and sometimes irrigation systems designers to select the proper irrigation system network components for the farm due to varies planning factors such as plant type and water source and characteristics, (Islam *et al*., (2019); Mansour *et al*. (2015, 2016 and 2019); Ayyad *et al*. (1990); El-Ghareeb *et al*. (1991); Leithy *et al*. (2010); El-Bassiouny *et al*. (2015); Yassen *et al*. (2011. 2018) and Bargaz *et al*. (2016), because of these reasons, the selection of pump, filters and other components of the irrigation control head unit is difficult. So, an expert is needed for the highly-qualified selection database, so it would be more appropriate to build up highly-qualified database to develop an expert system for this task focus on the Egyptian market. Awady *et al*. (2002) reported some criteria of the irrigation system selection processes of in certain situations depend on farm resources (soil, water, crop, labors, energy and costs). Virtual scores were allocated to different choices according to different qualifications. The assumption was based on experience and judgments and domain expert.

Expert system is defined as a computer program that designed to simulate solution of a problem based on expertise by using artificial intelligence. Moreover, artificial intelligence is a new science that deals with representation and use of knowledge. The goal of Artificial intelligence is to make computers more useful for reasoning, planning and communicating with humans. Kabany (2003) reported that the applications of expert system in agriculture were developed to give the agriculture high technology or techniques for greater profitability, also added that expert system applications should used by farmers or may be used by the experts themselves including consultants and advisory specialists, as well as specialists in research, extension and agribusiness. Mahmoud and Hassan (2008) stated that the expert system is expressed as an artificial intelligent applications of computer program to solve problems by simulating human reasoning processes, relying on belief, logic, and rules of their opinion and experience. Motameni (2010) reported that the expert system is expressed as an artificial intelligent applications of computer program that can be designed by experts to transfer their knowledge to other peoples who need to those skills. Shervan *et al*. (2013) reported that the Expert System is software which can replicate the thinking and reasoning capacity of humans based on some facts and rules presented to it. Doukhan (2011) indicated that the constructed expert system (CHEMIGAT-ES) has the potentiality of applying the principles of dynamic programming, which maximizes of the net profits of the effective chemigation management based on qualifying all available observable evidenced, under diverse field status and condition. Arafa and Shalabi (2016) revealed that irrigation system and its hydraulic performance analysis play a crucial role in improvement chemigation management efficiencies. They also indicated that for solid-set sprinkler irrigation system, data of the application practices of each chemical injector type revealed as agreement between the domain expert and developed expert system. Mehanna *et al*. (2009) and Cardoso and Lopes (2008) stated that the validation is a procedure consisting in verifying if the model is able to reproduce data, independently of those involved in its calibration. Hence, there are many purposes for validation, including establishment of overall credibility in the model, assessment of how “right” or “wrong” a model is in a given application, along with production of evidence to support a specific configuration of input data, parameter sets, and model structure are appropriate for a particular application. The aim of this study was to validate TSDICU expert system for selecting the proper components of drip irrigation system control head unit under the Egyptain market conditions.

Materials and Methods

The developed expert system of this research was applied on the experimental farm of Agricultural Production and Research Station (APRS), National Research Centre (NRC), El-Nubaria District, El-Behaira Governorate, Egypt, to validate a rule-based program named TSDICU-ES (Technical Specifications of Drip Irrigation control unit-Expert System). The flowchart of selection of irrigation network components is given in Fig. (1).

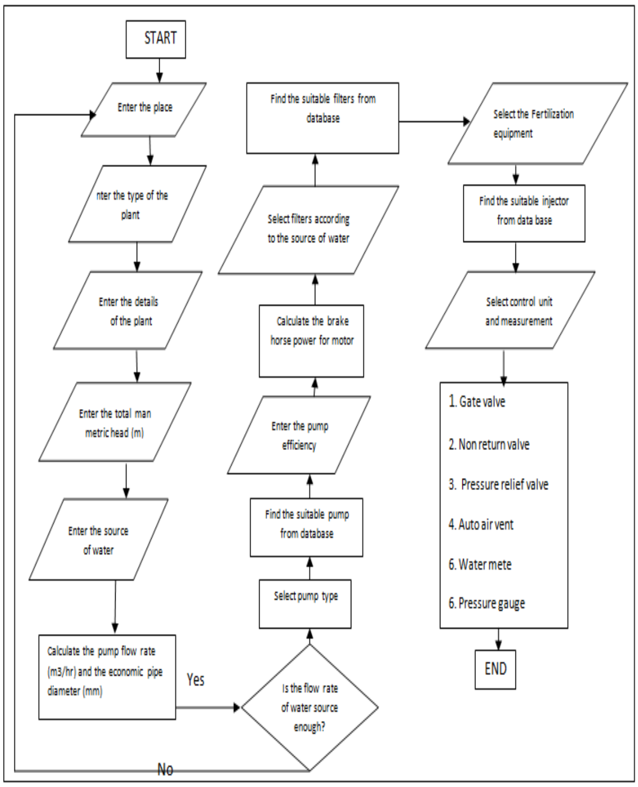

Fig. 1 : The flowchart of selection of irrigation system control head unit components.

Description of study area and data for validation process

1. Irrigation water source characteristics

The program offers two options of irrigation source (well or canal), in this study, irrigation water was obtained from an irrigation channel (Nile water) going through the experimental site, with pH 7.3, and an electrical conductivity of 0.60 dS m^{-1}.

2. Cultivated crops

There are three crop types for Al-Nubaria (12 feddan of mango, 5 feddan of orange and 3 feddan of lemon) have been selected for the validation purposes of the program.

3. Cultivated and harvesting dates

Based on the meteorological data of the region, the cultivated and harvesting dates will be from 15- March to 18-August for orange, from 15-March to 7-October for mango, and from 15-March to 18-August for Lemon, respectively.

Growing stage lengths, crop coefficients (K_c), crop height (*h*) of the four growth stages (initial stage, crop development stage, mid-season stage, and late season stage) for mango, orange and Lemon crops according to single-K_c are presented in Table (1).

For the planning of irrigation system in irrigated agriculture, the decisive factors are the irrigation requirements of plants (IR) according to the calculations. The irrigation requirements are estimated by the following equation (Keller and Bliesner, 1990):

$$IR = \frac{I \times (1 + LR) \times 4.2}{Ea}$$

Where:

IR = Irrigation requirements (m^3 ha^{-1})

I = irrigation depth that infiltrates the soil (mm),

LR =leaching requirements, (assumed 20 %), and

Ea= water application efficiency (surface drip irrigation=90%)

Table 1 : Reference values of Period, Lengths, the single crop coefficient (K_c) and crop height (*h*) for the four growth stages of mango, orange, Lemon (Doorenbos and Pruitt, 1977).

Stage	Period	Days	K_c	*h*, m
		Mango		
Initial stage	15-Mar: 15-April	30	0.5	0.30
Development stage	16-April: 1-Jun	45	0.6	0.64
Mid-season stage	2-Jun: 16-Aug	75	0.7	1.0
Late season	17-Aug : 7-Oct	50	0.6	1.0
		Orange		
Initial stage	15-Mar: 15-April	30	0.45	0.30
Development stage	16-April: 16-May	30	0.60	0.64
Mid-season stage	17-May: 17-Jul	60	0.65	1.0
Late season stage	18-Jul : 18-Aug	30	0.42	1.0
		Lemon		
Initial stage	15-Mar: 15-April	30	0.45	0.30
Development stage	16-April: 16-May	30	0.65	0.64
Mid-season stage	17-May: 17-Jul	60	0.7	1.0
Late season stage	18-Jul : 18-Aug	30	045	1.0

Results and Discussion

The experimental site crtiera for the valdation process of TSDICU-ES

The experimental farm of APRS has 8 hectare have be distributed as follows:

Mango	60 %
Orange	25 %
Lemon	15 %

The total irrigation water requirements (ET_c)

47 m^3/h for Mango + 20.2 m^3/h for Orange + 12 m^3/h for Lemon
= 79.2 m^3/8 hectare.

Validation process for selecting the control head unit components

Pump Selection

The required discharge was chosen according to the highest requirement of water for the studied crops. and the highest irrigation requirement in El-Nubaria is 47 m^3/h for Mango. Before the pump selection, the program controls, the adequacy of the water source capacity (required flow rate) and compares the required flow rate with the suitable pump specifications in the database of TSDICU-EX. In a negative condition, the user is warned instantly. Pump selection: The user should put all the required data in the inputs screens (Location details, soil data, crop data, and irrigation options and irrigation system data), Before the pump selection, the program controls the adequacy of the water source capacity (required flow rate), next for going to the first step of choosing the irrigation system control unit specifications which will be choosing the pump specifications and type. Then, the suitable pumps are searched out from the database according to required flow rate and total manometric head. After the pump selection according to different firms in the Egyptian market, the features such as water horse power are calculated by flow rate and the total required manometric head. The constraints of the pump selection in the expert system are related to the database (Plate, 1). The selected pump specifications using TSDICU-EX has a very good agreement with the exist pump in the experimental farm.

Filter Selection

Selection of filters was depended on the flow rate of the chosen pump, so that the discharge of filter is more than the flow rate of the chosen pump by about 25% according to the reverse washing operations. As shown in Plates (2 and 3), the results of the program are media filter (36 inch diameter, and with quantity of 3) and screen filters with 3" of inlet and outlet diameter, total flow rate 60 m^3/h, and filtration grade 160 micron and these are the same specifications of filters in the study region.

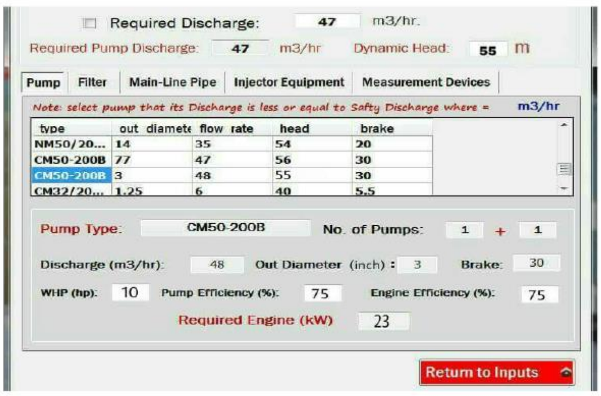

Plate (1): The output screen for choosing the pump.

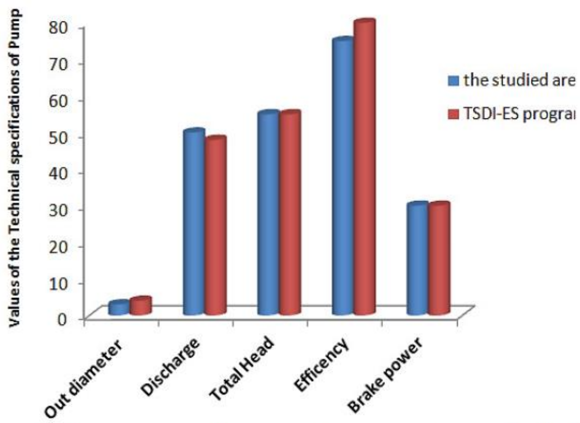

Fig. (2): A comparison between the selected pump by TSDICU-ES program and the existed pump in the study region.

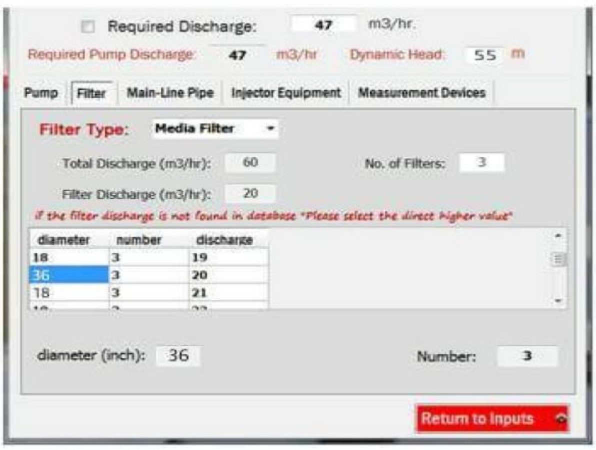

Plate (2): The output screen for choosing the media Filters.

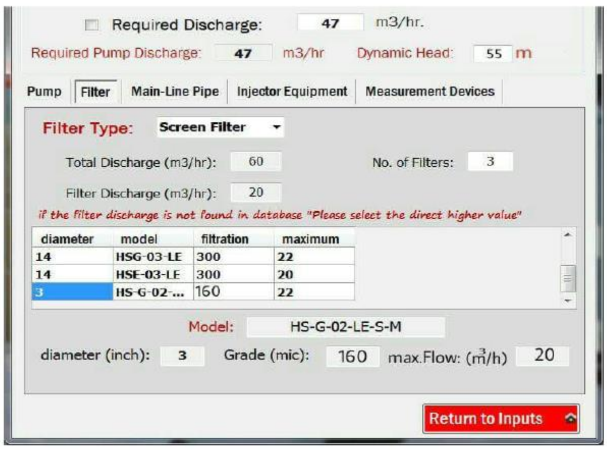

Plate (3): The output screen for choosing the screen Filters.

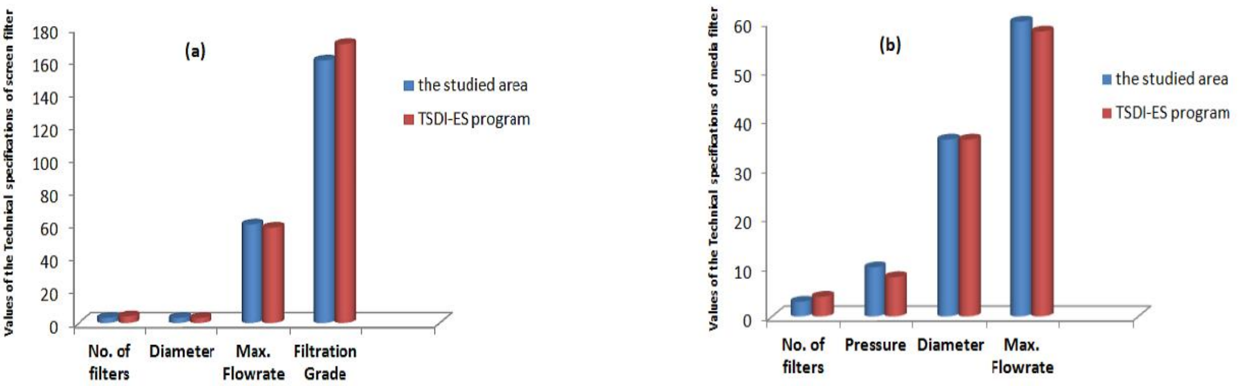

Fig. (3): A comparison between (a) media filter specifications, and (b) screen filter specifications selected using TSDICU-ES program and the existed in the studied farm.

Fertilization Equipment Selection

The next step is choosing the proper fertilizing device; Plate (4) and Table (2) shows the recommended fertilizers injection equipment (Venturi with inlet 2 inch diameter) for the studied region.

Table 2 : The outputs for choosing the fertigation equipment

Type of fertigation equipment	Venturi
Inlet/outlet connection (inch)	2
Inlet pressure (bar)	3
Outlet pressure (bar)	2
Injector rate (l/h)	50

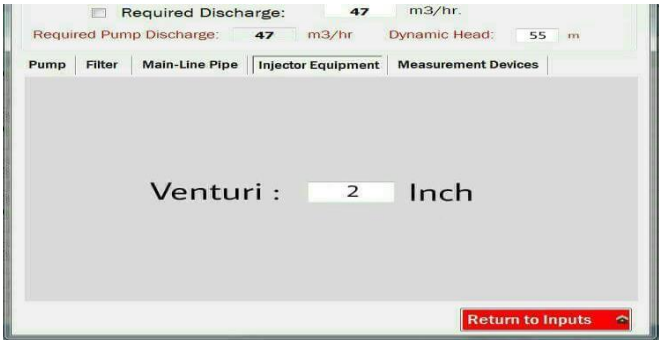

Plate 4 : The output screen for choosing the Fertilizers Equipment.

Measurement and Protection Equipments Selection

The next step is choosing the proper attached valves and other components of the drip irrigation control unit. Plate (5) shows the recommended gate valve (8 inch), non-return valve (8 inch), pressure relief valve (3 inch), air vent (3 inch), vacuum breaker (3 inch), water meter, and pressure gauge.

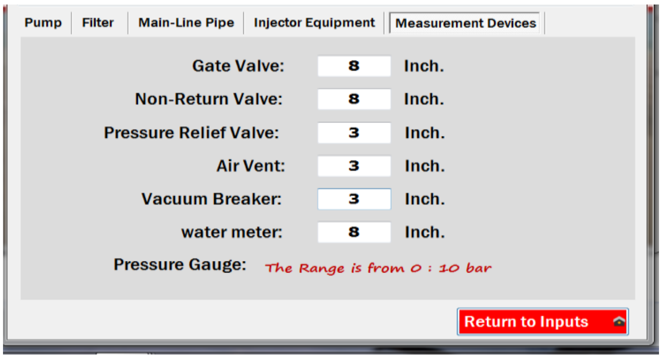

Plate 5 : The output screen for choosing the protection Equipment for the studied region.

Conclusion

TSDI-ES program is an addition of the new scientific knowledge in the application of techniques of expert systems in the field of irrigation systems in Egypt and that the accuracy of the selection of the most appropriate technical specifications of each component of the drip irrigation network, leading to greater efficiency in the use of irrigation water and subsequently increases crop productivity.

Generally, TSDICU-ES program is a good tool for irrigation management, helps farmers, researchers and experts to know the appropriate specifications of the control head unit of drip irrigation system components, which available in the Egyptian market.

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