

The Use of Netafim Hydrocalc Program Version 2.21, for Designing Drip Irrigation Arrangements

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Abstract: - This paper describes a computer program for designing efficient drip irrigation facilities namely HydroCalc v.2.21 from the Netafim company. This concern for an arrangement of this type is justified by the superior advantages offered by drip irrigation compared to other methods. After presenting the steps and how to use the program in Section 3 is presented a case study on an area of 80 ha in Banloc locality, Timiș County.

Key-Words: - HydroCalc program, irrigation arrangements, drip irrigation, localized irrigation, designing software, case study, computer modeling.

1 Introduction

Israeli company Netafim is the global leader in smart drip and micro-irrigation solutions for a sustainable future. The company offers to its customer's software for designing drip irrigation facilities entitled HydroCalc version 2.21.

Localized irrigation is a method of irrigation that responds well to environmental requirements. It allows the water supply only to the root system of plants, with the help of pipes and watering devices placed on the soil surface or buried in the soil at small depth. The method is used mainly in high yield crops and lately it has been used also to other cultures. Specific conditions required for the use of this method are: areas with scarce water resources, soils with light texture, high multiannual temperatures, high frequency and intensity winds. It has two technological options: drip irrigation and irrigation through perforated ramps [1].

The advantages of localized irrigation are: evaporation is reduced because only a small area of land is watered; limiting the wetted surface reduces the growth of weeds; slow application of water improves water infiltration rate in heavy soils; losses through leaching and runoff are also very small; frequent watering keep a low concentration of salts in the soil so it can be used for irrigation and water with a higher concentration of salts; the amount of fertilizer can be reduced with localized irrigation; water control and fertilizers make the use of localized irrigation to meet environmental standards; power consumption is reduced.

The disadvantages for the localized irrigation are: localized irrigation systems presents a high risk of clogging due to the small size of the drippers diameters; argillaceous textured soils can accumulate salts when is used water with medium or large mineralization; watering systems are fragile; for the crops with high density localized irrigation can be expensive due to the large number of pipes and drips necessary [2].

The distribution of water, drop by drop, only near the root system of the plant, leads to the same balance of water used by plants with low water consumption, only about 30% of water consumption used by sprinkler and only 10 - 18% of water used in furrows irrigation, leading thus to reduce the costs for water supply.

The applicability of this method is meeting in wine and orchard arrangements, greenhouses and solariums in temperate climate areas while reducing water resources caused by increased droughts.

Therefore the concerns for the use of this method of watering in many areas of the world are justified.

The paper applies the software described for a drip irrigation arrangement of 80 ha in Banloc locality, Timiș County.

2. Problem Formulation: presenting the opportunities for design calculations and how to use the program.

The Software Design for irrigation system is designed to help users define their irrigation system parameters. They will be able to run the program with all parameters corresponding to the output analysis, and modify input data in order to fit proper the irrigation system set up.

Some parameters can be selected from a list by the system; whereas others are introduced by the user according to their needs so that they do not conflict with the limitations of the program [3].

The software package includes a main window opening five computer programs, a window set tongue and a database that can be modified and updated by the user.

The Transmitters program (Emitters) calculates the cumulative pressure loss, the average flow rate, the water flow rate, etc. in the selected transmitter. It can be modified to suit the desired parameters of the irrigation system.

The Secondary program (SubMain) calculates the cumulative pressure drop and flow rate of the water in the secondary water distribution pipeline (unique or telescopic). It changes to accommodate the necessary parameters of the irrigation system [3].

The Main Pipeline Program (Main Pipe) calculates the cumulative pressure drop and the flow rate of water into the main water distribution pipe (single or telescopic). It changes in order to accommodate the necessary parameters of the irrigation system

The Modeling Excellence Program (Shape Wizard) helps transferring the necessary system parameters (the flow rate of input side, the minimum pressure) from issuance program (Emitters) to the Secondary program (SubMain).

The program Valves (Valves) calculates the friction loss in the valve depending on the parameter data.

The program Changes (Shifts) calculates the irrigation norm and the number of shifts required according to the given parameters. The window Settings (Settings) helps setting the language of the program and to establish whether to use Metric or the USA measurement system [3].

The wetting line is considered from the hydraulic point of view as a pressured pipeline with flow distribution. To meet the Christiansen criteria we have the possibility to select the type of drip (depending on the work flow and pressure) and a set of standard watering pipe diameters.

For sizing the watering line the input required by the program are: watering method drip or perforated ramps, drip type, drip step, the dropper flow, the watering pipe material, the work pressure for the watering pipe [3].

After that is inserted the pipe diameter to which is added in the program the watering schedule, the

irrigation pipe characteristics: inner diameter coefficient k_d , and coefficient k . The user inserts the segment length, and final downstream pressure calculation method (which may be required based on the length of the watering pipe, or on the basis of the variation of flow rate and uniformity based on the watering).

After running this subprogram calculation results are displayed in the same window, with the possibility to open a window with additional results, namely a window with a graph representing the variation of pressure along the pipe watering [3].

The secondary pipe is a pipe under steady pressure on several sections. The length and the flow of each section that compiles a secondary pipe are obtained from calculating the number of possible simultaneous functionality watering lines on a section. Here is no need to meet the Christiansen criteria, only to balance the pressure in the network nodes (with a margin of error of $\Delta h \leq 0.5$ m).

As in the secondary pipe we will proceed for the main pipe.

3. Problem Solution: case study. Designing a drip irrigation arrangement on an area of $S=80$ ha, using the Hydrocalc program v.2.21.

The Drip irrigation arrangement is located in the Banloc locality, Timis County, Romania over an area $S = 80$ ha. Studies for the project include pedological study, geotechnical study, hydrogeological study, overall site plan. The Technical Project includes the location, the beneficiary, the project and general information about the conditions of climate, soil hydrogeology and according to these and the type of spatial data agropedameliorative measures [4].

The case study was provided with the site plan of the arrangement, the perimeter arrangement, pedological soil mapping, hydrogeology mapping and the elements specific for the culture and irrigation. Thus, the area was divided into 20 operational units also called sole of 4 ha each with a square of side 200 m. The culture plan was designed for three crops so that 60% of the surface is used for the first crop and the other two crops are grown on about 20% of the arrangement. The source of irrigation water for the area considered ($S_{\text{tot}} = 80$ ha) is the Bârzava River. The irrigation Norm for the three crops is $2500 \text{ m}^3/\text{ha}$, to be given in time $T = 10$ days.

We must note that the entire planning is done on a flat surface with slope 0. Measurement units used below are those used by the program.

The sizes, diameters, flow rates, pressures for the dimensioned pipes are presented as follows:

Sizing the watering pipe line the first crop: on each plot of 4 ha will be distributed a watering pipe for two rows of plants, as the diameter of the wet bulb of the dropper gives sufficient volume of water to cover the portion of the plant surface to be wetted on both rows. Therefore the subprogram drip lines (Emitters) is started from the main menu of the program. The first step is the introduction of the input data as the following: Enter the line type drip - drip line; Type drainer - drainer Button; Step of the drip 0,8 m; Dropper flow is 2.00 l/h; Pipe material is PE (polyethylene); Pressure of the pipe is 2.5, type pipe - 32 mm with an inner diameter of 28.8 mm and another 3 features introduced automatically by the program according to the type pipe; The segment length is 200 m; the downstream chosen pressure to is 10 m. The next step consists in choosing the calculation method that method of calculation based on data lengths drip line then click on Calculate. After running the program we have the following calculations: The total number of drip is 250 drips on a drip line; The total length is 200 m that we used as a single section. Upstream pressure is 10.21 m; The pressure lost is 0.21 m; The water flow is 0.21 m/s.

Fig. 1 Data input for the watering pipe line – crop 1

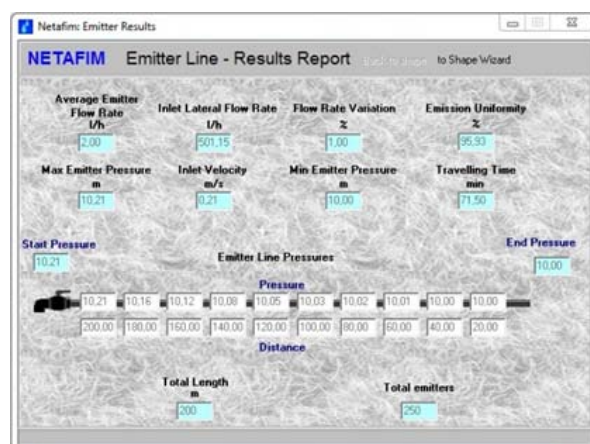


Fig. 2 The additional results for the watering pipe line – crop 1 calculus

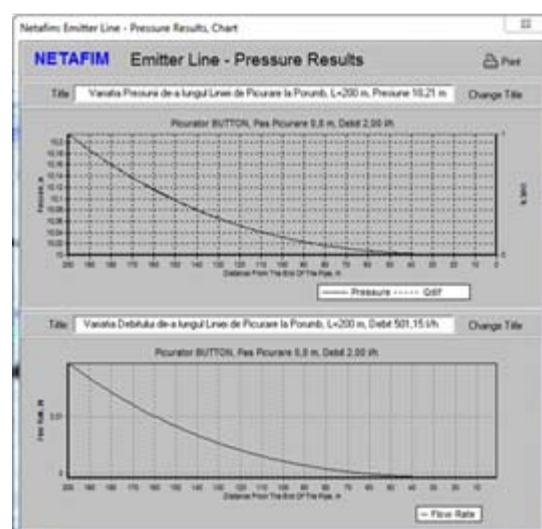


Fig. 3 The graphical representation the watering pipe line – crop 1 calculus

The same actions are done for the watering pipe line used to the crops 2 and 3 where some changes occur. The input data are: the line type drip - drip line; Type of the drainer - drainer Button; Step of the drip 0.4 m; Dropper flow is 1.00 l/h. The remaining inputs rest the same as for the watering pipe line sizing for the first crop. After running the program we have the following calculations: Total number of drip is 500 drips on a drip line; The total length is 200 m that we used as a single section. Upstream pressure is 10.29 m; The pressure lost is 0.29 m; The water flow is 0.25 m/s

Sizing the secondary pipe for the first culture: for the area designated to the first culture will be distributed four pipelines 600 m long to distribute the required flow for an optimal operation of irrigation pipes. Each secondary line will be equipped downstream with a valve and a pressure regulator in order to obtain optimal flux flow.

The dimensioning calculation is done in the secondary subprogram (SubMain). Input data: downstream flow is 501.15 l/h resulted from the calculation of the watering pipe line, then we enter the number of side watering pipes 75. The type of chosen pipe depends on the pressure loss that must be as small as possible. The pipe type is - PVC with a coefficient of friction of 150, and Class 4 pipe. It is chosen a nominal diameter of 180 mm and an inner diameter of 170 mm, and a segment length of 600 m. In this subprogram we must introduce the upstream pressure, this thing being made until we obtain the desired pressure downstream which must be the watering inlet of the pipe line 10.21 m.

After running the program we obtain the following results: Total length is 600 m because we used a single section; Pressure loss is 0.26 m and the cumulative pressure loss is just 0.26 for the same reason, the downstream pressure is 10.24 m; The upstream pressure is 10.50 m; The water flow is 0.47 m³/s; Inflow in the secondary pipe is 38.09 m³/h.

Fig. 4 Data input for the secondary pipe – crop 1

Distance from the beginning m	Delta h m	Height m	Pressure Loss m	Pressure m
0,000	0,000	0,000	0,000	10,500
56,000	0,000	0,000	0,063	10,437
112,000	0,000	0,000	0,052	10,385
168,000	0,000	0,000	0,043	10,342
224,000	0,000	0,000	0,034	10,308
280,000	0,000	0,000	0,026	10,282
336,000	0,000	0,000	0,019	10,263
392,000	0,000	0,000	0,014	10,249
448,000	0,000	0,000	0,007	10,242
504,000	0,000	0,000	0,005	10,237
560,000	0,000	0,000	0,000	10,237
600,000	0,000	0,000	0,000	10,237

Min Pressure: 10.24 m at distance 488.00 m from the beginning
 Max Pressure: 10.50 m at distance 0.00 m from the beginning
 Req. lat. pressure: 10.21 m

Fig. 5 The additional results for the secondary pipe – crop 1

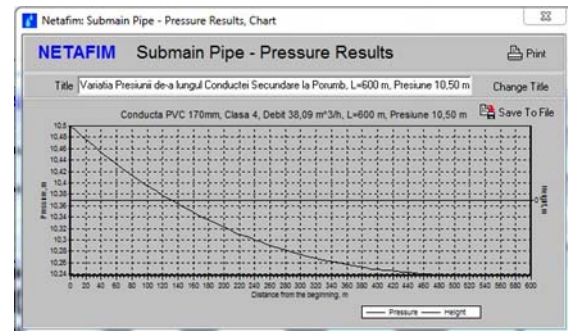


Fig. 6 The graphical representation for the secondary pipe – crop 1 calculus

In the same way we will calculate the data for crops 2 and 3 taking into consideration the related changes: segment length is 400 m; the downstream flow is 577.40 l/h, 50 side watering lines, the rest of the input data are the same as for the first crop. The results of running the program: total length 400 m; Pressure loss of 0.11 m; Cumulative pressure: 0.11 m; Upstream Pressure 10.41 m; Downstream pressure 10.30 m; Water flow rate 0.36 m³/s; Inflow 29.45 m³/h

Dimensioning the Main pipe is done in subprogram Main Pipe but on four sections of 200 m each. The input data to calculate the first 3 sections are: Pipe type – PVC, Friction coefficient 150; Nominal diameter 280 mm; Class 6; The inner diameter 266.8 mm; Segment length 200 m, the inflow 59.50 m³/h 119 m³/h, 186.55 m³/h; upstream pressure of 10.6 m, 10.8 m, 11.3 m After calculation we obtained the following results for the last segment of 200 m: inflow 186.55 m³/h; The pressure loss 0.50 m; downstream pressure 10.8 m; Water speed rate 0.93 m/s. The input data for the last section of the main pipe: Type pipe PVC; Friction coefficient 150;

The nominal diameter is 315 mm; Class 6; inner diameter 300.2 mm; The segment length is 200 m; 11.81 m upstream pressure and therefore a flow rate of 254.10 m³/h. The calculations made by the subprogram have the following results: total length 200 m; Inflow in pipe 254.10 m³/h; Pressure loss 0.50 m 11.31 m downstream pressure, The water flow rate is 1 m/s.



Fig. 7 Data input for the main pipe – crop 1

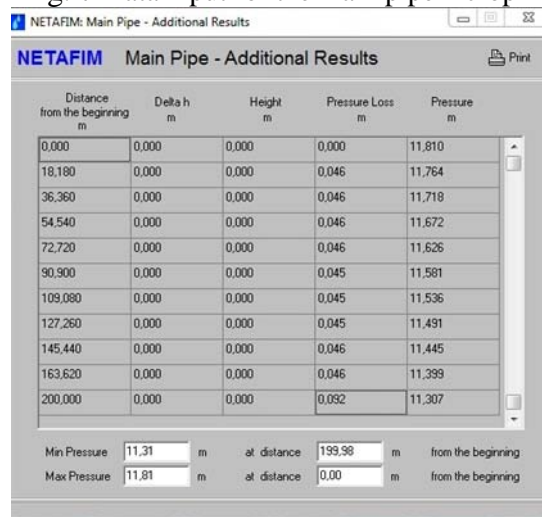


Fig. 8 The additional results for the main pipe – crop 1

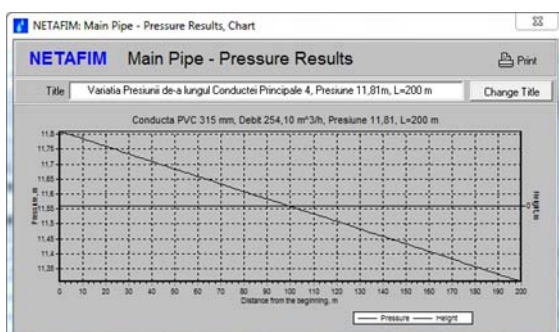


Fig. 9 The graphical representation for the main pipe – crop 1 calculus

Following the calculation of the last section of the main pipe we obtain the data necessary for the entering section throughout the irrigation system

The calculations are completed with the entire network piesometric line drawing (watering lines, the secondary pipes, main pipes, pumping stations) pressure balancing checking all the nodes that compile the network and hence the final results of the flow for the pumping station $Q_{SP} = 254.10$ m³/h, and the pressure pumping station $H_{SP} = 11.81$ m. Depending on these characteristics we can choose the pumps composing the pumping station.

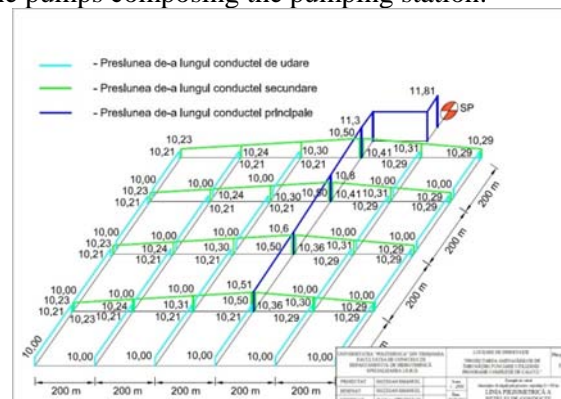


Fig. 10 Graphical representation of the pressure lines during the entire irrigation system

4. Conclusion

The software used for designing the drip irrigation arrangement in this particular case is one of many that exists in area of irrigation. We mention only

- IRRICAD a stand-alone, graphically based, computer aided design package developed specifically for designing pressurised irrigation or water supply systems [5].
- AquaFlow, Toro's drip irrigation design software. Now available as a web application, AquaFlow can be accessed and used online or downloaded to your computer for offline use [6].
- Nelson Irrigation professional software creates irrigation designs that help complete system design, project organization, quotes, or sprinkler uniformity analysis [7].

It is easy to set up a simple cost sharing program for drip/localized irrigation, but programs must be carefully structured to maximize all benefits that are achievable. Local authorities and investors must recognize that their goals must be different and therefore the programs must be chosen accordingly [8].

The multiplicity and variability of situations that may arise lead to the use of numerous methods and computer programs that offered various solutions with varying degrees of effectiveness [9].

Manual calculation methods have lost territory to the computing based programs systems due to both

higher risks for errors and because they do not provide detailed results. Software design for irrigation arrangements present efficient irrigation facilities through the approach of many factors involved in these processes. In designing land improvement facilities are taken into account climatic and soil factors, pointing out that they are accurate and detailed, at daily or even more specific (hourly), the data being used more strictly in terms of not using approximate values only in special cases and generally very rare.

Computer modeling techniques allow easier identification and correction of errors before launching the calculation and afterwards by using specialized procedures and sub-procedures in this area. The internet allows fast data transfer between designers, contractors and beneficiaries of the drainage or irrigation systems, and also working the system "network designing and operation".

The infrastructure of such modeling programs can be easily connected to GIS and GPS systems, so that data from satellites on topography and hydrological information of certain areas may be imported in real time, stored in the database and then used in making forecasting on desired phreatic level, forecasting that will later be easily verified also through satellite data.

It is observed that human intervention in an irrigation study can be minimized by using the existing technical infrastructure at this time which has numerous advantages: no field trips required for data taking; reduce personnel costs; easy identification of possible errors, the human factor is willing to made this kind of mistakes the even from initial data input into the system; prompt correction of errors compared to information obtained from statistical databases; provides very accurate forecasts about a certain phenomenon; minimizing the approximations which obviously leads to a very low level of errors; easy communication between designer, contractor work and the beneficiary; the possibility to follow the evolution of a drainage or

irrigation system with graphics that allows viewing numerous complex indicators of efficiency in operation, etc.

Another particular advantage is that the software can be changed relatively easily from one geographical area to another and can in most cases be improved by the introduction of new sub-procedures that can address to a number of issues. However, there are disadvantages, mostly related to the costs required to create a statistical databases, the costs of the satellite connection and creation of the necessary calculation program effectively.

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