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DH V 2.0, A Pocket PC Software to Evaluate Drip Irrigation Lateral Diameters Fed from the Extreme with on-line Emitters in Slope Surfaces

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1. Introduction

Modernisation in irrigation systems allows farmers to adapt easily to requirements in crop production to contribute to environmental protection and optimize water resources, among others. The majority of the processes in the modernisation of the irrigation systems imply the change of surface irrigation systems to pressure systems. One of the main pressure irrigation systems is drip irrigation (Valiantzas, 2003; Yitayew et al., 1999; López, 1996).

High water use efficiency is a feature on drip irrigation systems (Ko et al., 2009; Rodríguez-Díaz et al., 2004; Yitayew et al., 1999). Precision in water and fertilizers application under adequate design conditions is another advantage of this irrigation system (Bracy et al., 2003; Pedras and Pereira, 2001; Holzapfel et al., 2001).

The design of a drip irrigation system calculation implies two phases: agronomic design and hydraulic design. For the agronomic design some specific data are needed (crop water demand, type of soil and data of drip emitters, among others). The hydraulic design is based on several data (characterization of chosen emitter, field topography, etc.). In order to design an irrigation subunit (drip line and sub main pipes), it is necessary to combine the hydraulic calculation (flow, diameters and pressure of drip line and sub main pipes) with the irrigation net distribution plane. Drip line calculation is the first part in the hydraulic design of a drip irrigation system.

Drip line calculation is integrated in the hydraulic design of drip irrigation subunits (Yildirim, 2007; Provenzano and Pumo, 2004; Ravikumar et al., 2003; Anyoji and Wu, 1994; Wu, 1992; Wu and Gitlin, 1982). As in the design of drip irrigation system, in drip lines calculation the agronomic and the hydraulic design phases are included. Moreover, in the drip line design some specific agronomic features are used (plant frame, crop water demand...) (Cetin and Uygan, 2008; Narayanan et al., 2002). The number and the distribution of the emitters are the results of the design (Gyasi-Agyei, 2007; Medina, 1997).

For the future design of micro-irrigation systems several aspects must be considered. Some of these aspects were established in 2004 by Kang and Liu that presented the challenges to design micro-irrigation systems in the future. Firstly, to develop more perfect methods in order to minimize the total cost of a whole system (e.g. da Silva et al., 2005; Kuo et al., 2000 and Ortega et al., 2004); other aspect is the improvement of present-day methods by

applying modern geographic information sciences such as GIS (geographic information system), RS (remote sensing) and GPS (global position system) for computerized input of field topographic information; and finally, to develop intelligent computer software with functions where this field topographic information can be input automatically, layout and parameters of a whole system can be optimized automatically, and ground plans and installation maps can be created automatically. This software achieves the last challenge partially. Nowadays this software is designed just for drip line calculations in specific conditions but new tools are currently being implemented as part of this project.

The objective of this paper is to show a new version of software (DH V 2.0) capable of evaluating the adequate commercial diameters in the design of a pipeline for drip irrigation (micro-irrigation) systems with several changing conditions.

As the crop grows it is usual to add new emitters in order to supply the increasing crop water needs. In some cases, when the farmer wants to increase the plant density or decides to change the crop maintaining the existing irrigation system, the system has to be adapted to the new situation. This implies to change the number of emitters in the drip line to fulfill the new water requirements. In this case, if the flow and pressure required at the beginning of the drip line are known, it is very useful to provide software that allows the user to know if drip line is ready to these changes. It is necessary for this software to be quick and precise. This software would indicate immediately the farmer or the installer what decision he would make.

Some software for drip irrigation design is used under Windows operative systems (Pedras et al., 2008; Rodrigo and Cordero, 2003) but not in mobile devices for agronomic and hydraulic design in drip irrigation. One adequate solution is the installation of developed software for mobile devices as Smartphone or pocket PC. In the last years several programming languages have been used in mobile devices. One of this is LabVIEW®, which is a revolutionary system of graphical programming used for applications that includes acquisition, control analysis and data presentation (Berg et al., 2008; Lajara and Pelegrí, 2007). This software is being used in engineer applications because of its great versatility and simplicity of use.

This document shows a new version of the developed software (DH V 2.0) for this type of mobile device that uses LabVIEW PDA® as programming language (Molina-Martínez and Ruiz-Canales, 2009). This is an executable freeware and it is not necessary to install LabVIEW PDA®. This programming language has some advantages. During programming phase, this it allows to configure several algorithms that compute in parallel. Additionally, it allows implementing algorithms in a friendly and intuitive way. Another advantage is presented during the phase of use: its graphical interface elements to collect and show information are very attractive and easy to use. The use of this freeware is limited to the next conditions: a) drip lines fed from the extreme, b) with a varying slope terrain, c) on-line emitters at the same distance from the beginning of the pipe to the first emitter and between emitters and d) standard dimensions of the emitter connection. This software can be downloaded from the next links:

DH V 2.0 (with slope surfaces support): <http://decibel.ni.com/content/docs/DOC-4771>.

DH V1.0 (without slope surfaces support): <http://decibel.ni.com/content/docs/DOC-3851>

2. Theoretical considerations

The theoretical base of used equations in the hydraulic design of drip irrigation considers that flow distribution in a drip line is coming close to a continue distribution. A description of the calculation procedure is detailed in the next lines.

Head losses Dh (m) in a pipe of Length (m), have been calculated with the next equation:

$$Dh = F \cdot J^* \cdot Length \quad (1)$$

Where F is the Christiansen's reduction factor in a pipe with emitters located at the same distance from the beginning of the pipe to the first emitter and between emitters. J^* ($m \cdot m^{-1}$) is the unit head losses coefficient that includes major and minor head losses.

The equation used to estimate the Christiansen's reduction factor is:

$$F = \frac{1}{1 + \beta} + \frac{1}{2n} + \frac{\sqrt{\beta - 1}}{6n^2} \quad (2)$$

Where the value of β is 1.75 in the Blasius formula for polythene pipes and n is the number of emitters in the drip line.

Unit head losses J^* , have been determined using an empirical formula that includes the minor head losses of the emitters by means of the next expression:

$$J^* = J \frac{Ee + fe}{Ee} \quad (3)$$

Where Ee (m) is the distance between emitters and fe (m) is the equivalent length of the emitter that depends on the inner Diameter (mm) of the drip line (Table 1) to estimate the minor head losses. This software version is only for on line emitters and standard dimensions of the emitter connection.

Unit major head losses, J ($m \cdot m^{-1}$), have been determined using the Blasius's formula (with a standard temperature of 20° C) in polythene pipes:

$$J = 0.473 \frac{(Q_{dripline})^{1.75}}{Diameter^{4.75}} \quad (4)$$

Where Diameter (mm) is the inner diameter of the drip line and $Q_{drip\ line}$ ($l \cdot h^{-1}$) is the flow in the beginning of the drip line. $Q_{drip\ line}$ value is obtained multiplying the number of emitters N_e in the drip line by the nominal flow of the emitter q_e ($l \cdot h^{-1}$).

Diameter (mm)	fe (m)
10.3	0.24
13.2	0.15
16.0	0.11
18.0	0.08
20.4	0.07
28.0	0.04

Table 1. Equivalent length of pipe fe (m) as a function of the inner pipe diameter (mm).

Pressure distribution in a drip line is shown in Fig. 1 and Fig. 2. Fig. 1 is the pressure distribution in an upward slope terrain. In Fig. 2, the pressure distribution in a downward slope terrain is presented.

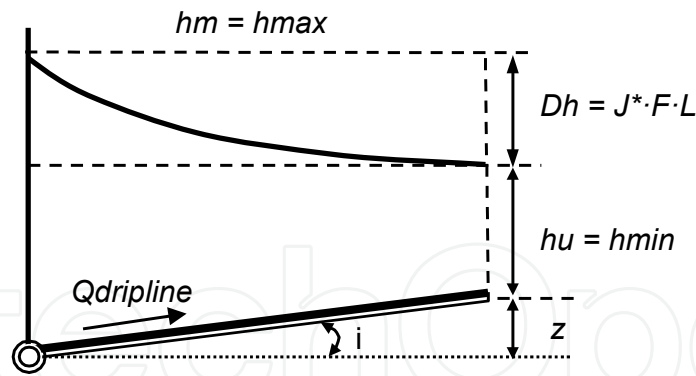


Fig. 1. Pressure distribution in a drip line fed by the extreme in an upward slope terrain.

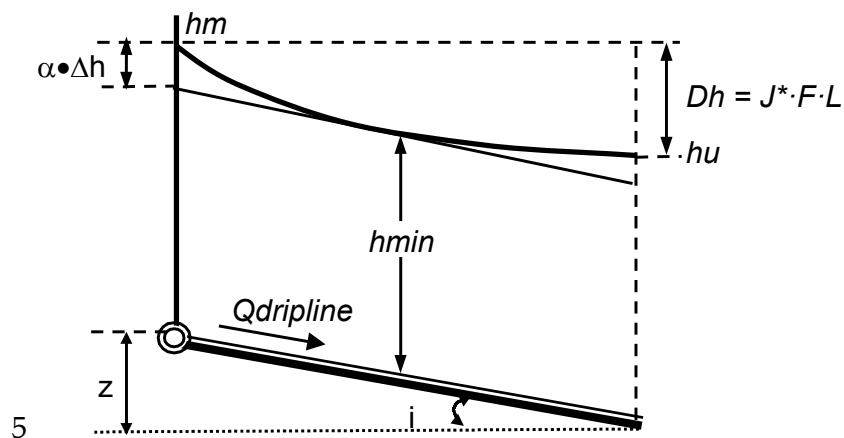


Fig. 2. Pressure distribution in a drip line fed by the extreme in a downward slope terrain.

In these figures, the maximum of pressure, h_{max} (m), coincides with the pressure in the beginning of the drip line, h_m (m), which is determined by means of the eq. (5):

$$h_m = h_a + 0.75 \cdot Dh + 0.5 \cdot z \quad (5)$$

h_a (m) is the average pressure in the drip line.

z (m) is the unevenness between the beginning and the end of the drip line. This value is obtained by the next equation (6), multiplying the slope i ($m \cdot m^{-1}$) by the pipe Length (m):

$$z = i \cdot Length \quad (6)$$

Fig. 1 illustrates the pressure distribution in an upward slope terrain. In this case, the minimum pressure, h_{min} (m), is the pressure in the last emitter, h_u (m), which is determined by:

$$h_u = h_m - Dh - z = h_a - 0.25 \cdot Dh - 0.5 \cdot z \quad (7)$$

Fig. 2 shows the pressure distribution in a downward slope terrain. For this case, there are two situations.

- Strong slope, where the absolute value of the slope i ($m \cdot m^{-1}$) is larger or equal to J^* ($m \cdot m^{-1}$) ($|i| \geq J^*$). In this situation, minimum pressure, h_{min} (m), of the drip line coincides with the pressure in the beginning of the drip line, h_m (m) (eq. 5). Maximum pressure, h_{max} (m), is the pressure value in the last emitter, h_u (m) (eq. 7).

- b. Soft slope. For this situation, the absolute value of the slope i (m m^{-1}) is less to J^* (m m^{-1}) ($|i| < J^*$). In a drip line with a descending soft slope, the minimum value of pressure h_{\min} (m) is placed along the drip line. This value is obtained by the next expression:

$$h_{\min} = h_m - \alpha \cdot Dh = h_a + (0.75 - \alpha) \cdot Dh + 0.5 \cdot z \quad (8)$$

where α depends of F and the ratio z/Dh , by means of this equation:

$$\alpha = 1 + \frac{z}{Dh} + 0.375 \cdot \left(-\frac{z}{Dh} \right)^{1.57} \quad (9)$$

Maximum value of pressure h_{\max} (m) is the higher value between h_m (m) and h_u (m), determined by eqs. 5 and 7.

For all the slope situations in a drip line (horizontal terrain, rising slope terrain and descendent slope terrain) if the difference of pressure $h_{\max} - h_{\min}$ is under the value h_p (m), the commercial diameters are adequate. This value h_p is the pressure tolerance and is a required data.

3. Software

The graphic interface of the developed software consists of three tabs:

- a. In the tap "Home" at the top of the screen, the data for calculation is introduced, and at the lower part valid commercial diameters are shown in green colour by means of light emitting diodes (LED) (see Fig. 3).

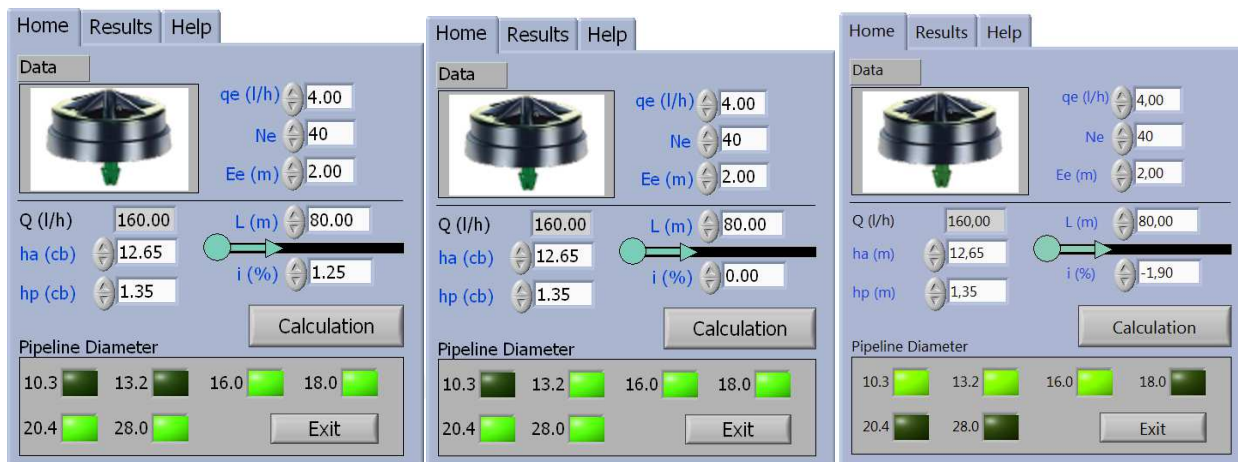


Fig. 3. "Home" tab for a horizontal terrain, an upward slope terrain and a downward slope terrain.

Required data are: nominal flow of the emitter q_e (l h^{-1}), number of emitters N_e , drip line length Length (m), distance between emitters E_e (m), average pressure in the drip line h_a in meter water column (m), pressure tolerance h_p (m) and slope i , in percentage. After data introduction the button named "Calculations" has to be pressed in order to show the results in the frame. An example (Fig. 4) is developed with three slope values ($i = 0.0\%$; $i = 1.25\%$; $i = -1.90\%$) and the same rest of the data ($q_e = 4 \text{ l h}^{-1}$; $N_e = 40$ emitters; $E_e = 2 \text{ m}$; Length = 80 m; $h_a = 12.65 \text{ m}$; $h_p = 1.35 \text{ m}$).

In the example of Fig. 4, only the indicators of the adequate commercial diameters (see theoretical considerations) are coloured in green. In Fig. 4 the main results in three situations of a drip line are shown: no slope terrain ($i = 0.0\%$), rising slope terrain ($i = 1.25\%$) and descendent slope terrain ($i = -1,90\%$).

- b. The tab named “Results” (Fig. 4) shows, for every commercial diameter, the head losses in the drip line Dh (m), maximum pressure h_{max} (m) and minimum pressure h_{min} (m). At the lower part, it is shown a comparative vertical bar graphic that indicates the level of the allowed pressure tolerance hp (m), in blue, and, green in colour, the values of the difference $h_{max} - h_{min}$ in meters for every diameter. Moreover, as it is shown in Fig. 4, on the left of every screen, only the indicators of the adequate commercial diameters are again coloured in green, and all the result values are shown. Fig. 4 shows the results for the three examples detailed in a).

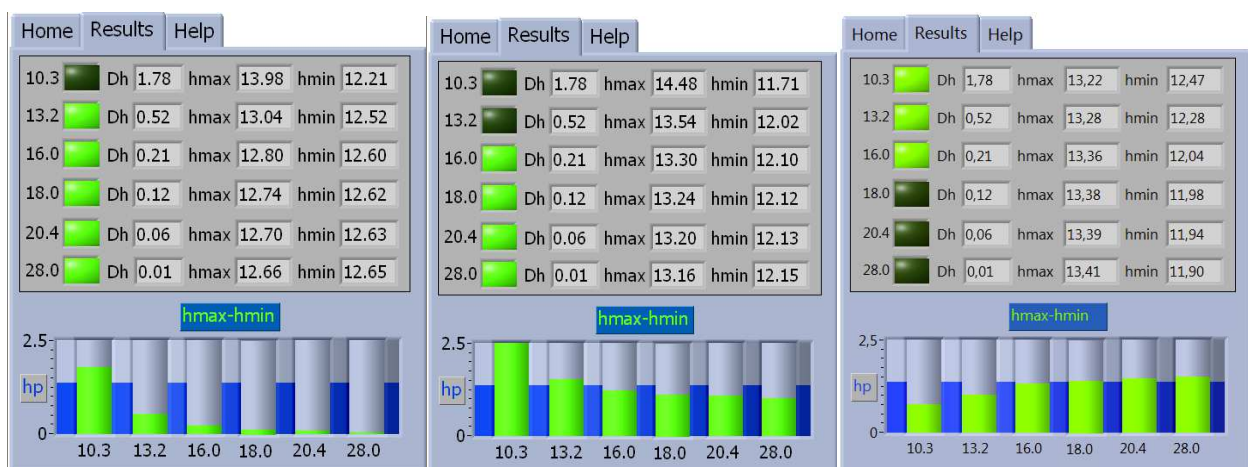


Fig. 4. “Results” tab for a horizontal terrain ($i = 0.0\%$), a upward slope terrain ($i = 1.25\%$) and a downward slope terrain ($i = -1,90\%$).

- c. The last tab “Help” shows the contacting data for the authors.

The software flow chart is developed under a while loop structure that allows ending the software execution by means of the button “Exit” (see Fig. 3). The button “Calculation” determines the true and false values (TF) of a case structure included in the while loop. Pushing this button, the case structure takes the true value and the internal programming is carried out. Fig. 6 shows the software flow chart used to determine whether the pipe with a diameter of 13.2 mm could be used in the drip line considering general data entry. In parallel calculations are obtained: a) z (m) and i ($m \cdot m^{-1}$) values from required slope data, i (%), and the drip line length, Length (m); b) flow at the beginning of the drip line, Q_{drip} line ($l \cdot h^{-1}$) from nominal flow of the emitter q_e ($l \cdot h^{-1}$) and the number of emitters N_e ; c) Christiansen’s reduction factor F , introducing eq. (2) in a “Express VI Formula” and taking as data input the number of emitters N_e ; d) Dh , J^* , h_m and h_u values using eqs. (1), (3), (5) and (7). The specific values for 13.2 diameter are expressed as Dh 13.2, $J^*(13.2)$, $h_m(13.2)$ and $h_u(13.2)$, respectively. These results are calculated with a double precision floating point (DBL) and showed in the screen (see Fig. 5).

The entry value hp is compared with the difference between h_{max} and h_{min} . In Fig. 4, the subtraction value is shown in the screen, in a vertical bar diagram (tap “Results”). Initially, the user has introduced hp value in the tap “Home”. The software numerical control hp is joined to the vertical progress bar $hp2$ in order to show in the tap “Results” the previously introduced

value h_p . (See part e) in Fig. 5). The corresponding LED is green in colour if this subtraction is less than h_p . In the opposite case, LED is not coloured (true and false values, TF).

In the case structure has been used another one for selecting the necessary calculations if drip pipeline is on a horizontal, rising or descendent terrain. If slope i (%) is larger or equal to zero, is assigned a true value and will be executed the associated code for horizontal or rising terrains (Fig. 6). In the opposite case, if slope i (%) is minor than zero, will be assigned the false value and will be executed the associated code for descending terrains (Fig. 8).

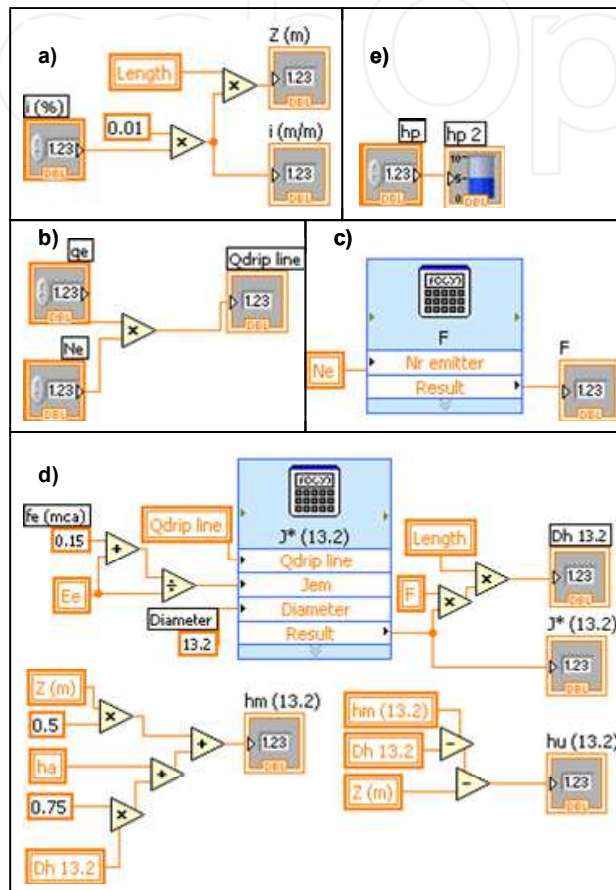


Fig. 5. Software flow chart.

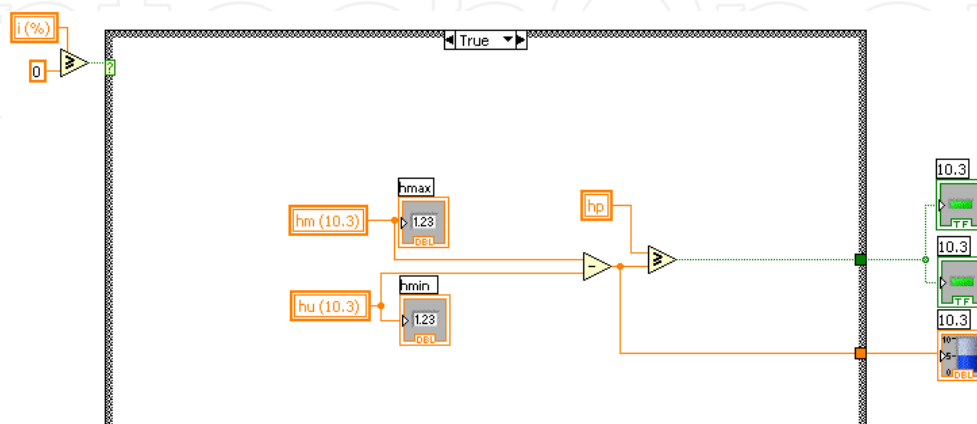


Fig. 6. Block diagram for drip lines in a horizontal or upward slope terrain. Pipe diameter of 10.3.

At the left-top corner of Fig. 6 the associated condition to the case structure is shown. Inside, is found the code that it would execute if the condition is true. Values h_m and h_u obtained previously will be shown in the indicators h_{max} and h_{min} of the tap "Results". The difference h_{max} minus h_{min} is obtained and it is compared with h_p value fixed by the user. If h_p value is larger than $(h_{max}-h_{min})$, then will be activated the LED diodes of the taps "Home" and "Results". $(h_{max}-h_{min})$ value will be shown in the graphic of the tap "Results". This last part of the calculation process is common for all the possible situations. Fig. 6 shows the cited process for a diameter of 10.3 millimeters.

When a descendent slope terrain is presented, a new case structure is executed. In this case, if the absolute value of the slope i ($m\ m^{-1}$) is larger or equal to J^* ($m.c.a.\ m^{-1}$), exit value is true and the code associated to strong slope terrains it will be executed (Fig. 7). If this value is minor than J^* ($m.c.a.\ m^{-1}$), then the code associated to soft slope terrains will be executed. In Fig. 7 and Fig.8 the processes for a diameter of 10.3 millimeters is shown.

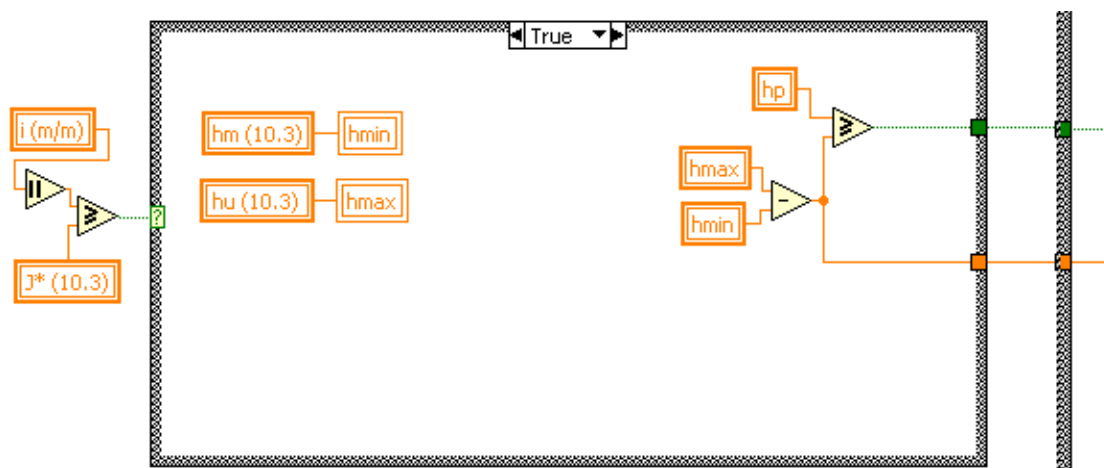


Fig. 7. Block diagram for drip lines in a strong downward slope terrain. Pipe diameter of 13.2.

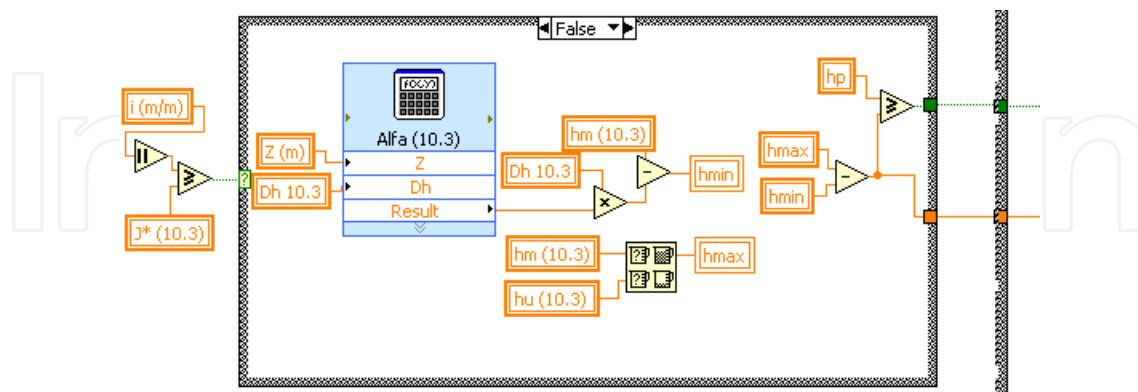


Fig. 8. Block diagram for drip lines in a soft downward slope terrain. Pipe diameter of 13.2.

A similar flow chart has been developed for the rest of every commercial diameter (10.3; 13.2; 16.0; 18.0; 20.4 and 28.0). These diagrams establish the algorithms to evaluate if the diameters of commercial pipes are adequate for the drip line, and the results are compared. All the results for every diameter could be shown in the console.

4. Case studies

In this Section two case studies considering upward and downward slopes are presented to demonstrate the validity and usefulness of our application. In order to do this, has to be taking in account the theoretical considerations of Section 2. The obtained results has to be compared with the obtained by the proposed application.

4.1 Upward-slope terrain

In this case an upward-slope land was considered with 16 mm laterals with emitters spaced every 3 meters. We needed to determine if emitters could be placed every meter without changing the irrigation lateral. In order to solve this case, the irrigation drip line would have to be calculated using the following data:

- The emitter data: $q_e = 3 \text{ l h}^{-1}$, $h_a = 10 \text{ m}$ (average pressure in the drip line is considered to be equal to the nominal pressure of the emitter).
- The drip line data: $N_e = 90$ (number of emitters), $E_e = 1$ (distance between emitters), $i = 0.3 \text{ m m}^{-1}$ (upward slope). The pressure tolerance is $h_p = 1 \text{ m}$.

Head losses D_h (m) in the pipe of length $Length$ (m), have been calculated with eq. 1:

$$D_h = F \cdot J^* \cdot Length = F \cdot J^* \cdot 90 \quad (10)$$

Using eq. 2 the Christiansen's reduction factor can be estimated as:

$$F = \frac{1}{1 + \beta} + \frac{1}{2n} + \frac{\sqrt{\beta - 1}}{6n^2} = \frac{1}{1 + 1.75} + \frac{1}{2 \cdot 90} + \frac{\sqrt{1.75 - 1}}{6 \cdot 90^2} = 0.3692 \quad (11)$$

The value of β is 1.75 in Blasius formula for polythene pipes and n is the number of emitters in the drip line.

Unit head losses J^* , have been determined using the empirical formula detailed in eq. 3:

$$J^* = J \frac{E_e + f_e}{E_e} \quad (12)$$

E_e (m) is the distance between emitters and f_e (m) is the equivalent length of the emitter that depends on the inner diameter $Diameter$ (mm) of the drip line (Table 1) to estimate the minor head losses. This software version is only for on line emitters and standard dimensions of the emitter connection.

E_e has been extracted from Table 1. The results for each candidate diameter are shown in Table 2.

Unit major head losses, J (m m^{-1}), have been determined using the Blasius's formula (with a standard temperature of 20° C) in polythene pipes (eq. 4).

$$J = 0.473 \frac{(Q_{dripline})^{1.75}}{Diameter^{4.75}} \quad (13)$$

Where $Diameter$ (mm) is the inner diameter of the drip line and $Q_{dripline}$ (l h^{-1}) is the flow in the beginning of the drip line. $Q_{dripline}$ value is obtained multiplying the number of emitters N_e in the drip line by the nominal flow of the emitter q_e (l h^{-1}). The results for each drip line diameter are described in Table 3.

Diameter (mm)	J* (m m ⁻¹)
10.3	$J^* = J \frac{1+0.24}{1} = J \cdot 1.24$
13.2	$J^* = J \frac{1+0.15}{1} = J \cdot 1.15$
16.0	$J^* = J \frac{1+0.11}{1} = J \cdot 1.11$
18.0	$J^* = J \frac{1+0.08}{1} = J \cdot 1.08$
20.4	$J^* = J \frac{1+0.07}{1} = J \cdot 1.07$
28.0	$J^* = J \frac{1+0.04}{1} = J \cdot 1.04$

Table 2. Unit head losses J* (m m⁻¹) for each candidate diameter.

Diameter (mm)	J (m m ⁻¹)
10.3	$J = 0.473 \frac{(90 \cdot 3)^{1.75}}{10.3^{4.75}}$
13.2	$J = 0.473 \frac{(90 \cdot 3)^{1.75}}{13.2^{4.75}}$
16.0	$J = 0.473 \frac{(90 \cdot 3)^{1.75}}{16.0^{4.75}}$
18.0	$J = 0.473 \frac{(90 \cdot 3)^{1.75}}{18.0^{4.75}}$
20.4	$J = 0.473 \frac{(90 \cdot 3)^{1.75}}{20.4^{4.75}}$
28.0	$J = 0.473 \frac{(90 \cdot 3)^{1.75}}{28.0^{4.75}}$

Table 3. Unit major head losses, J (m m⁻¹) for each candidate diameter.

Hence, with the values of F, J* and J, head losses Dh (m) have been calculated from eq. 10 (see Table 4).

Diameter (mm)	Dh (m)
10.3	5.42
13.2	1.55
16.0	0.60
18.0	0.33
20.4	0.18
28.0	0.04

Table 4. Head losses Dh (m) for each candidate diameter.

The maximum pressure coincides with the pressure at the beginning of the drip line, h_m (m), that is determined using eq. 5 for each drip line candidate diameter (see results in Table 5).

$$h_m = h_a + 0.75 \cdot D_h + 0.5 \cdot z \quad (14)$$

Diameter (mm)	h_m (m)
10.3	14.20
13.2	11.30
16.0	10.58
18.0	10.38
20.4	10.27
28.0	10.16

Table 5. Maximum pressure h_m (m) for each candidate diameter.

Unevenness between the beginning and the end of the drip line, z (m), is by eq. (6):

$$z = i \cdot \text{Length} = 0.3 \cdot 90 = 2.7\text{m} \quad (15)$$

In this case, the minimum pressure h_{min} is the pressure of the last emitter, h_u (m), that is determined by eq. 7 and shown, for each drip line diameter, in Table 6.

Diameter (mm)	h_u (m)
10.3	8.51
13.2	9.48
16.0	9.72
18.0	9.78
20.4	9.82
28.0	9.86

Table 6. Minimum pressure h_{min} for each candidate diameter.

Finally, the difference of pressure $h_{max}-h_{min}$, which coincides with h_m-h_u , is calculated in Table 7.

Diameter (mm)	$h_m - h_u$ (m)
10.3	5.68
13.2	1.86
16.0	0.87
18.0	0.60
20.4	0.45
28.0	0.31

Table 7. Minimum pressure h_{min} for each candidate diameter.

Since the pressure tolerance h_p has a value of 1 m, the commercial diameters 16.0, 18.0, 20.4 and 28.0 mm are adequate.

Thanks to the DH 2.0 application these data could be calculated in situ and provide instant feedback without making any manual calculation. The results obtained with the mobile device are shown in Fig. 9.

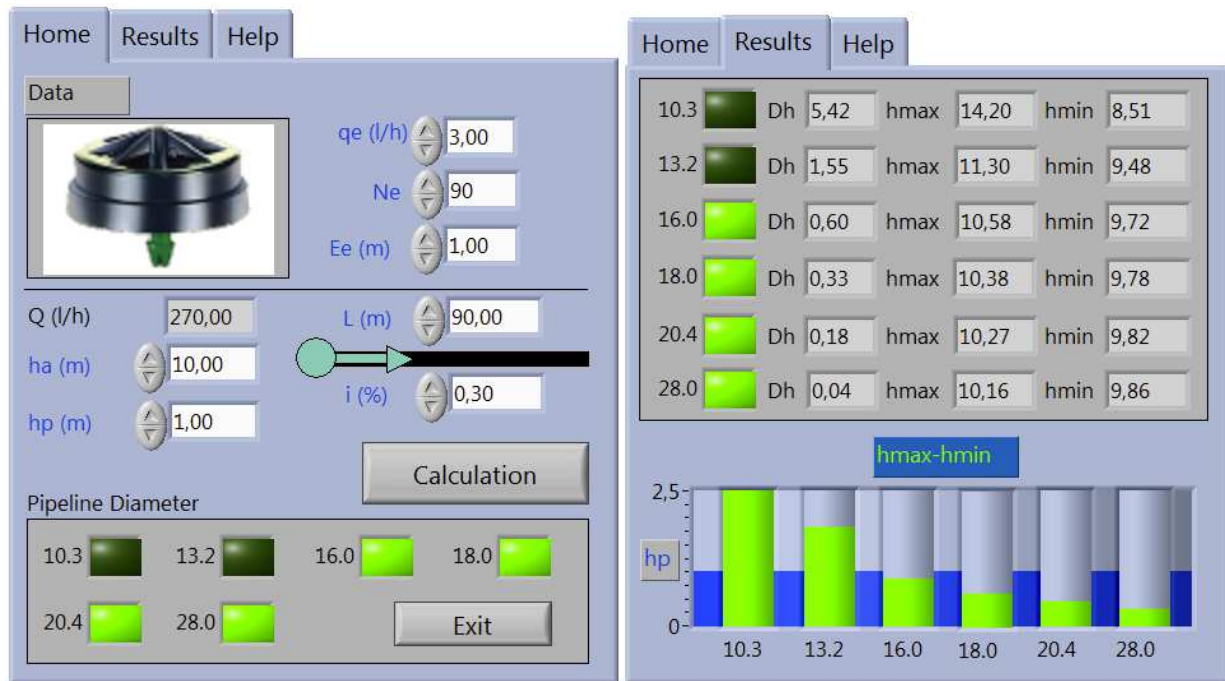


Fig. 9. Results for the case study obtained in situ with the mobile device.

4.2 Downward-slope terrain

In this case the diameter of a drip irrigation line had to be calculated to place it in a downward-slope land with a slope of $i = -0.034 \text{ m m}^{-1}$. Emitters with $q_e = 4 \text{ l h}^{-1}$ had to be used, placed every 2 m (E_e), with a total line length of 80 m (which gives an amount of 40 emitters). The datasheet of the emitter allowed to know that the nominal pressure of the emitter (which is considered to be equal to the average pressure in the drip line) had a value of $h_a = 12.65 \text{ m}$, and the pressure tolerance is $h_p = 1.35 \text{ m}$.

Diameter (mm)	f_e (m)	J (m m^{-1})	J^* (m m^{-1})	$ i \geq J^*$?	D_h (m)	z/D_h (-)	α (-)
10.3	0.24	0.0526	0.0589	No	1.78	-1.56	0.16
13.2	0.18	0.0162	0.0177	Yes	0.52	0.00	0.00
16.0	0.11	0.0065	0.0069	Yes	0.21	0.00	0.00
18.0	0.08	0.0037	0.0039	Yes	0.12	0.00	0.00
20.4	0.07	0.0020	0.0021	Yes	0.06	0.00	0.00
28.0	0.04	0.0005	0.0005	Yes	0.01	0.00	0.00

Table 8. Calculated values for different commercial drip line diameters in a downward-slope terrain.

The values calculated using theoretical equations from Section 2 are detailed in Table 8 and Table 9 for the different commercial drip line diameters.

Hence only the 10.3 mm diameter drip line fulfils the pressure tolerance condition (h_p) since $h_{max} - h_{min}$ (1.25 m) is lower than h_p (1.35 m).

Diameter (mm)	$\alpha \cdot Dh = h_m - h_{min}$ (m)	h_m (m)	h_{min} (m)	h_u (m)	$h_{max} - h_{min}$ (m)
10.3	0.27	12.59	12.33	13.58	1.25
13.2	0.00	11.68	11.68	13.88	2.20
16.0	0.00	11.44	11.44	13.96	2.52
18.0	0.00	11.38	11.38	13.98	2.61
20.4	0.00	11.34	11.34	13.99	2.66
28.0	0.00	11.30	11.30	14.01	2.71

Table 9. Calculated values for different commercial drip line diameters in a downward-slope terrain.

As is shown in Fig. 10, these values coincide with those calculated with the DH V2.0.

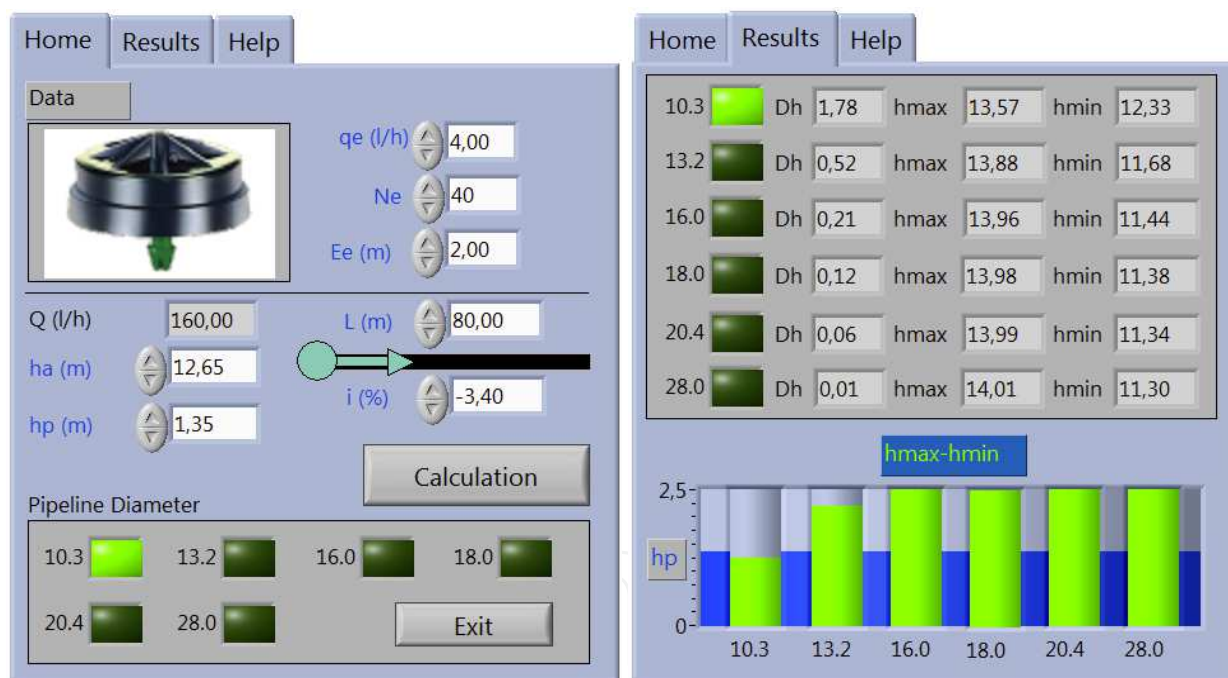


Fig. 10. Results for the case study obtained in situ with the mobile device.

5. Conclusions

This software allows users of drip irrigation systems to evaluate the sensibility to changing conditions (water needs, emitters, spacing, slope...) in all commercial polythene diameters of drip lines. These calculations are executed at once for every commercial diameter in a pocket PC. This allows to users makes these calculations immediately in the field without the need of moving to the office and using a PC.

Software has been developed with LabVIEW PDA®. This is an intuitive programming language and allows configuring several algorithms that compute in parallel at once.

This software version is limited to drip lines, with on line drippers, fed by the extreme with a slope terrain. It is an accessible freeware, contacting with authors or from the link (<http://decibel.ni.com/content/docs/DOC-4771>).

This software is limited but new tools are being implemented actually to develop the project and extend new calculations to the main parts of a pressurized irrigation system.

Finally, the validity and usefulness of the application have been verified with a case study.

6. Acknowledgments

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7. References

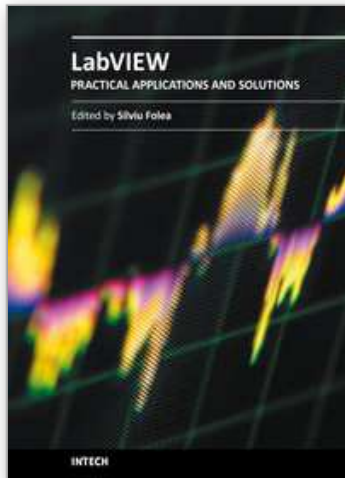
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