USERS MANUAL

Version 1.0

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Disclaimer

DripNet is a software program written in Visual Basic language, developed and copyrighted by the Mediterranean Agronomic Institute, Valenzano (BA). Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

Although a reasonable effort has been made to assure that the results obtained are correct, the computer program described in this manual is experimental. Therefore the author and the Mediterranean Agronomic Institute are not responsible and assume no liability whatsoever for any results or any use made of the results obtained from this program, nor for any damages or litigation that result from the use of this program for any purpose.

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I-Introduction

DripNet is a computer program that analyzes the performance of a drip irrigation network under fixed (pump or upstream reservoir) or variable (hydrant of an on-demand pressurized water distribution system) upstream pressure head. Using the network layout, topographical elevation, hydraulic design and emitters characteristics, the software generates the network characteristic curve and relates it to the hydrant or pump characteristic curve. The intersection point between network and pump/hydrant characteristic curves represents the effective working pressure and discharge of the drip system. By calculating the pipe friction losses in the network, the working pressure and discharge of each single emitter is obtained. Using different uniformity parameters, the performance and efficiency of the system is thus obtained.

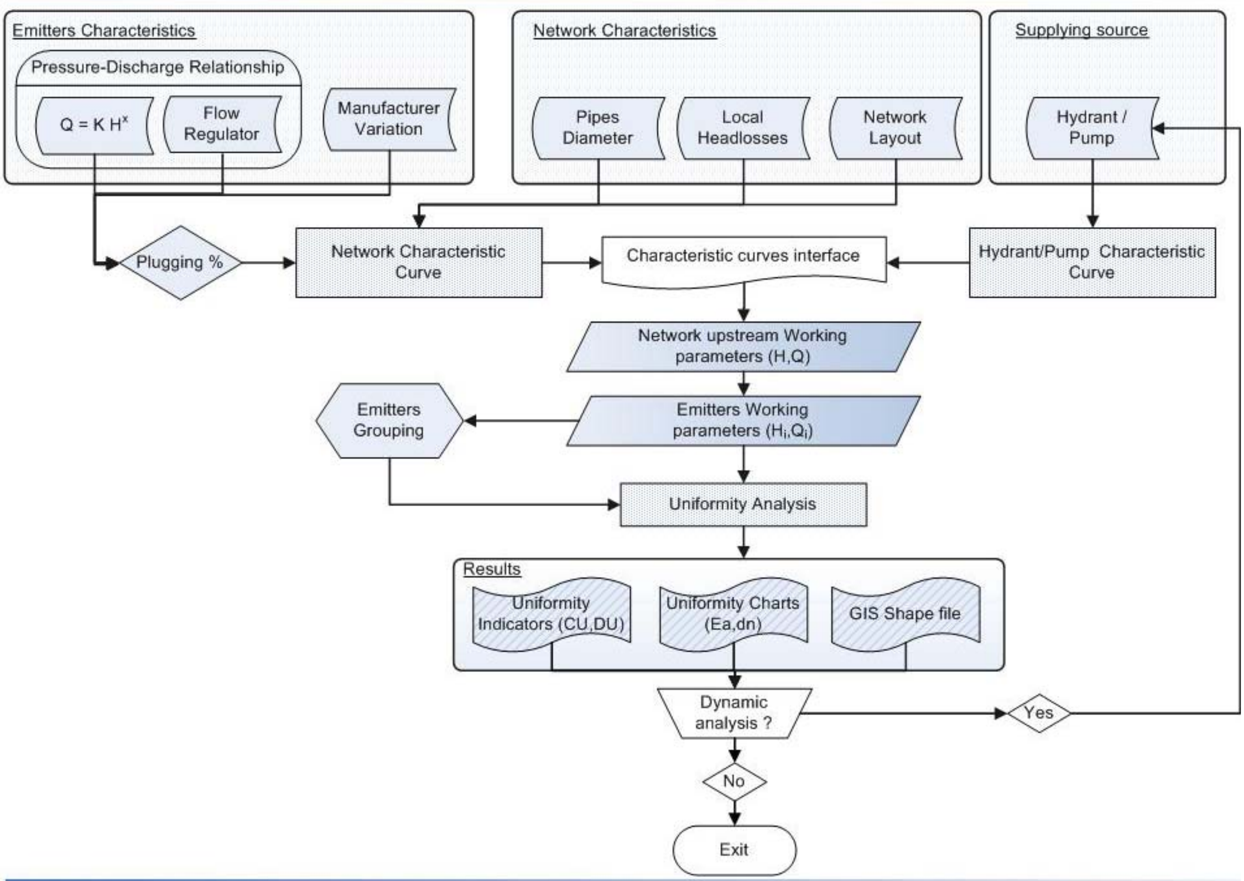


Figure 1: Flow chart of drip network analysis in "DripNet" software

II- Installing DripNet

DripNet version 1.0 is designed using VisualBasic.net to run under Windows XP / Vista operating system.

To install Optimum:

1. Select **Run** from the Windows Start menu
2. Enter the full path and name of the "**setup.exe**" file or click the browse button to locate it on your computer
3. Click the **OK** button to begin the setup process.

The setup program will ask you to choose a folder where optimum files will be placed. The default folder is **C:\Program Files\IAMB\DripNet**. After the files are installed your Start Menu will have a new item named DripNet, beside a shortcut will be placed on your desktop . To launch DripNet select this item off of the Start Menu, then select DripNet from the submenu that appears or simply click on the DripNet shortcut placed on your desktop.

Should you wish to remove DripNet from your computer, you can use the following procedure:

1. Select **Settings** from the Windows Start menu.
2. Select **Control Panel** from the Settings menu.
3. Double-click on the **Add/Remove** Programs item.
4. Select **DripNet** from the list of programs that appears.
5. Click the **Add/Remove** button.

Troubleshoots

- Since it was developed using .net framework, version 2.0 is required. If this latter was not installed on your computer, the installation wizard will ask you to install the .net framework. You can download the .net framework directly from the website of Microsoft or you can find it with DripNet installation CD under the name of "dotnetfx_ver2.exe". Note that installation of .net framework might take few minutes for complete installation. Once done, you can retry installing Optimum as previously described.
- Some computers could fail in registering "MapWinGIS.ocx", in that case you might need to install the MapWinGIS ActiveX control on your computer. To do that, click on"MapWinGIS44OCXOnly.exe" that you can find in the installation CD, or you can download it for free using the following link:
  http://www.mapwindow.org/download.php?show_details=2

N.B: Before start using DripNet software, be sure that the number format on your computer uses the "." as a decimal separator and not the ",".

III-Quick start tutorial

In the ***File*** main menu, you can find two items. ***Exit*** item that could be used together with the close button located on the top right of the main form to get out of the program and the ***New*** item used to start a new analysis or designing process.

1- Input Data

In this part of the tutorial we will analyze the performance of an existing drip irrigation network. The first step for evaluation is defining the layout and the hydraulic components and characteristics of the network, drippers and of the water supplying device (Upstream reservoir, hydrant or pump). For doing that, select from the main menu ***Edit Network*** and the following pages will be loaded:

- Hydraulic values
- Edit Network
- Drip
- Pump/Hydrant

1.a- Hydraulic values

In this page you must insert the full list of the pipe diameters with their cost that will be used in the optimization process. At the same time in the *Local Head losses* grid box, insert all the fittings that could create minor losses in the network together with their local loss coefficient (K_L).

- To add a new row or a new pipe or fitting, use the ***Add Row*** button .
- To remove the last row from any data grid, use the ***Remove Row*** button .
- To save the pipe list as ***".pipes"*** file or the fitting list as ***".fit"*** file use the Save button .
- To open a saved pipe list ***".pipes"*** or fitting list "***.fit*** "use the Open button .
- To choose the pipe roughness you can use the default values given by the software by selecting the ***Pipe materials from*** the drop down list otherwise uncheck the ***Default values*** checkbox and assign your roughness value in the ***Pipe Roughness*** textbox.

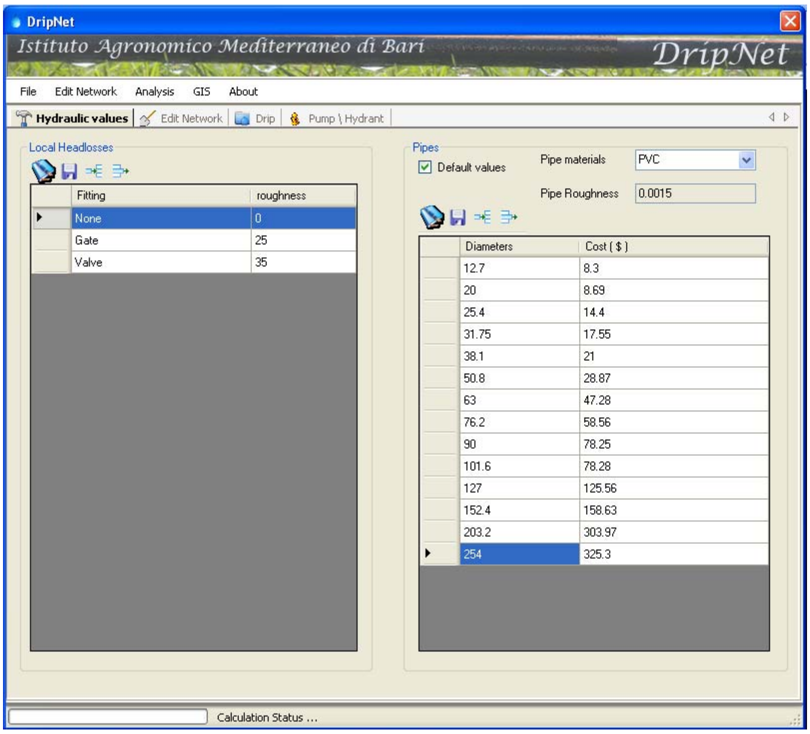
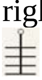


Figure 2: Example of Pipe diameters and fittings lists as used by DripNet software

1.b- Edit Network

Edit Network page is reserved to the description of the network layout, design and land topography. It is subdivided into 3 different tabs:

1. ***Network*** Tab: First step to do is to choose the layout of the network by clicking one of the 4 layouts presented on the top of the page (Fig.3).
   a.  layout button corresponds to a network made of a mainline and single lateral.
   b.  layout button corresponds to a network with laterals concentrated on the left side of the manifold.
   c.  layout button corresponds to a network with laterals located exclusively on the right side of the manifold.
   d.  layout button corresponds to a network where the laterals are attached to the both sides of the manifold.

Once you select the proper layout of your system, the necessary tables and text boxes for the required data will be enabled while the others will remain blocked. The input and output of this model is limited to the ***Pipe Reach Unit***, which is defined as a single reach of pipe having a given distance, same diameter and slope and carrying as a maximum one fitting.
Select one of the four layouts. Consequently, the *Mainline* group box will be automatically enabled for editing. In the numeric up down box named ***Mainline reach number*** assign the number of pipe reach unit corresponding to the mainline.

From the main line grid box, set the pipe reach unit length and assign a positive value for the slope to indicate a down hill and negative value for an uphill situation. Select your pipes diameter and fittings type from the drop down list that correspond to the lists added previously (Fig.12) in the ***Pipes and Fittings*** page**.**

The three buttons named ***Copy all Rows*** , ***Copy one Row*** and ***Copy selected Cell*** located at the top of any data grid are used to copy a selected row or cell into subsequent rows or cells to reduce the time consuming of data entry.

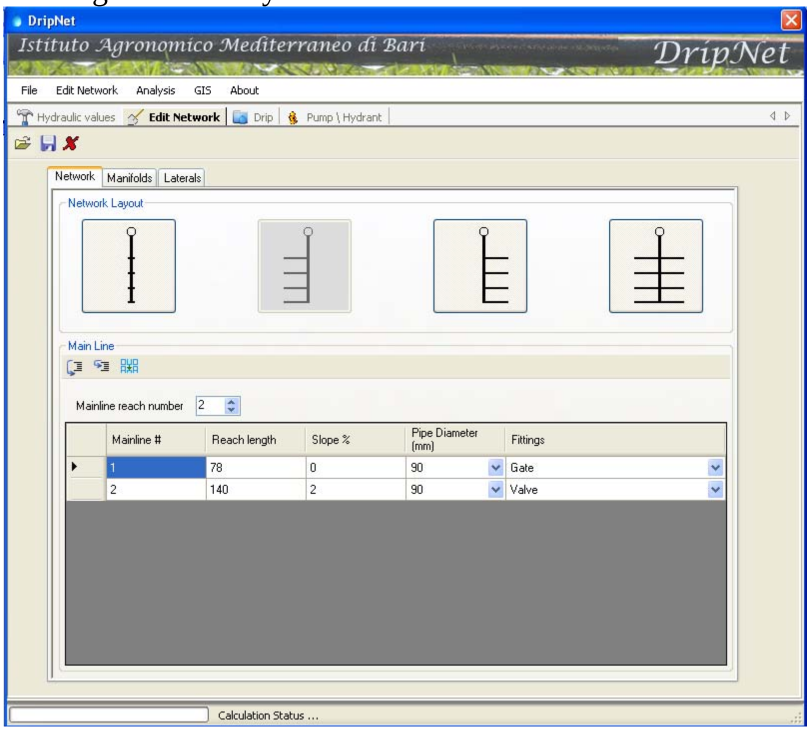


Figure 3: Network layout description as used by DripNet software

2. ***Manifold*** Tab: in this page select from the numeric up down box the number of laterals. Thus, based on the layout of the network the number of pipe reaches in the manifold will be added. For example, the number of laterals in layout should be always pair and to have a manifold reach, the number of laterals must be equal or higher than 4 (Fig.4). In case of layout, due to the absence of laterals, ***Number of laterals*** will be used to assign the number of sprinklers. For that reason an additional column will be added to the manifold grid box to assign the discharge in m^3/h for each outlet (sprinkler).

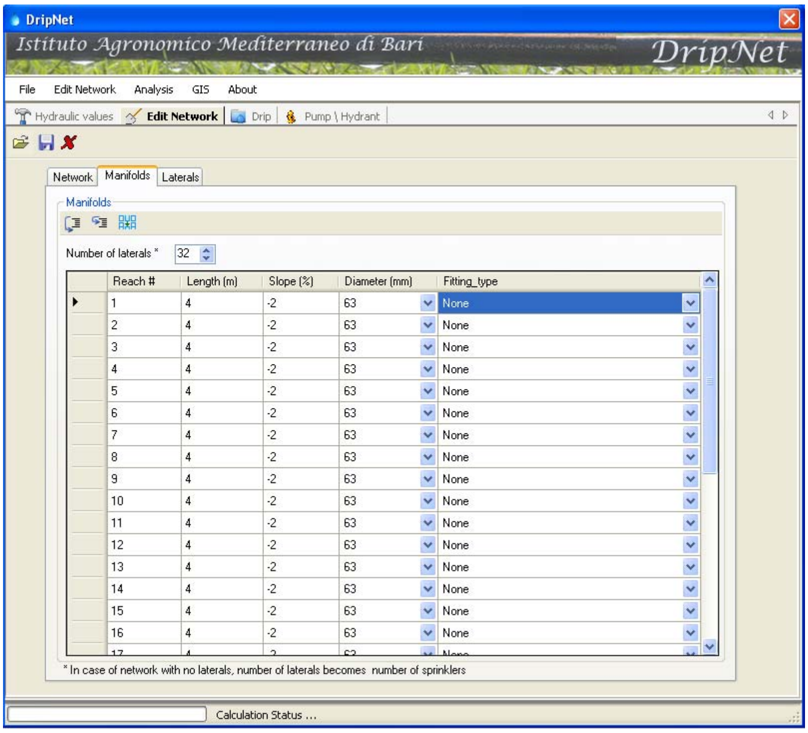


Figure 4: Data entry of manifold reaches as used by DripNet software

3. ***laterals*** Tab: In this tab we can find two grid box corresponding to data entry for left and right laterals respectively.

   Left laterals grid box is activated exclusively with or layout buttons. While right laterals grid box is enabled with or layouts. For each lateral of the network corresponds a row in one of these two grid boxes that are made of 5 columns necessary to insert the number of the lateral, number of drippers in that lateral, distance between drippers, average slope and the internal pipe size diameter.

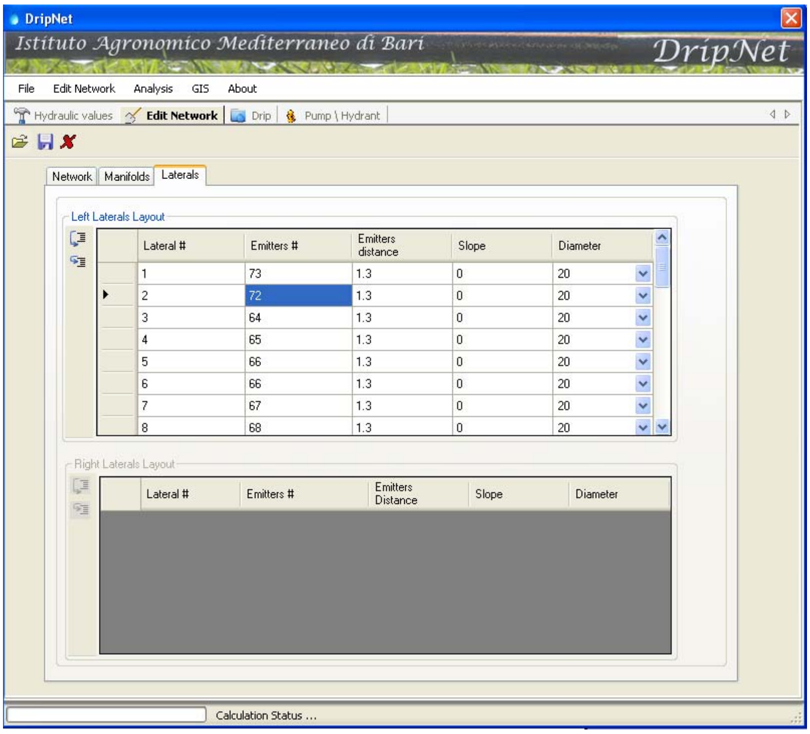


Figure 5: An example of data entry for the left laterals of a drip irrigation system

To save the network characteristic file, click on the ***Save network*** button located at the top left of the Edit Network page. The network file have a “.opt” extension. It should be mentioned that not only the network layout and hydraulic characteristic is saved but also the list of pipes and fittings too. Load network and New buttons are used to open an existing network file “.netd” and to create a new one respectively.

1.c- Drip

In this page, the user most insert the characteristics of the drippers which include the pressure-discharge relationship equation, manufacturer variation, plugging percentage and the number of emitters per plant.
Some new types of emitters are supplied with flow limiters that ensure a constant discharge (Q_{max}) once the emitter pressure surpass a certain level (H_{Qmax}), as shown in the following figure:

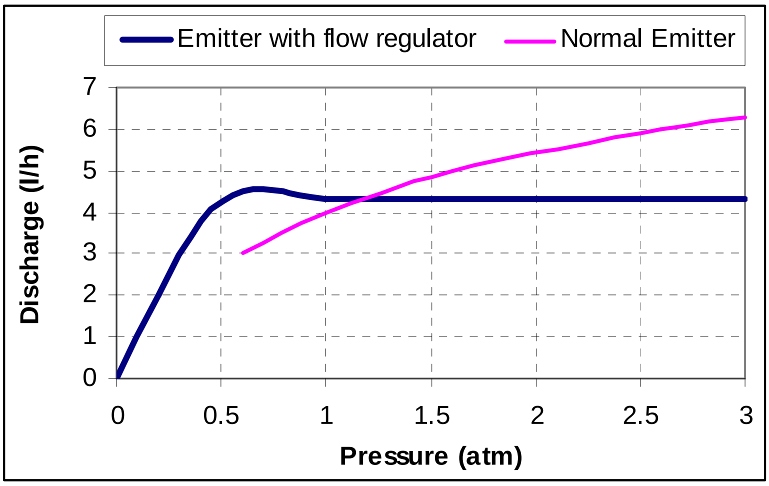


Figure 6: Emitters discharge with($H_{Qmax} \approx$ 0.75 atm, $Q_{max} \approx 4.3$ l.h^{-1}) and without a flow regulator (H_{min}=0.6 atm, H_{max}=3 atm)

In order to simulate the effect of pressure variation on emitters discharge the following equations were used:

For normal emitters (use the ***Normal Emitter*** checkbox):

$$Q = KH^x \qquad for \qquad H_{min} \le H \le H_{max} \tag{1}$$

For emitter with flow regulator (use the ***Emitter with flow regulator*** checkbox and insert $\mathbf{Q_{max}}$ and $\mathbf{H_{Qmax}}$ in their appropriate text box):

$$Q = KH^x \qquad for \qquad H_{min} \le H \le H_{Qmax} \tag{2}$$

$$Q = Q_{max} \qquad for \qquad H_{Qmax} \le H \le H_{max} \tag{3}$$

Where:

- H_{min} : minimum working pressure
- H_{max} : maximum working pressure
- Q_{max} : Maximum discharge fixed by the flow regulator
- H_{Qmax}: Pressure above which the flow limiter maintains a constant discharge Q_{max}

K and x values of the equ.1 or equ.2, are calculated using the least square fitting method (by clicking on the fit curve button) on pressure-discharge pair data (inserted in their appropriate grid box using the add row button and the remove row button) as described hereafter:

$$x = \frac{n\sum_{i=1}^{n}\left(ln\,H_i\;ln\,Q_i\right) - \sum_{i=1}^{n}\left(ln\,H_i\right)\sum_{i=1}^{n}\left(ln\,Q_i\right)}{n\sum_{i=1}^{n}\left(ln\,H_i\right)^2 - \left(\sum_{i=1}^{n} ln\,H_i\right)^2} \tag{4}$$

$$a = \frac{\sum_{i=1}^{n}\left(ln\,Q_i\right) - x\sum_{i=1}^{n}\left(ln\,H_i\right)}{n} \tag{5}$$

Where:

$$K = e^a \tag{6}$$

n: number of measured points to be fitted

Wu (I-Pai Wu, 1996) affirmed that ***manufacturer's variation*** (CV_m) of micro irrigation emitters could range between 2 % and 20 %. Therefore, this variation could be simulated by DripNet using a random percentage variation (ΔQ_i), with $\Delta Q_i \in \left[-CV_m, +CV_m\right]$, on the initial discharged emitter (Q_i) as following:

$$Q_i = Q_i + \Delta Q_i \tag{7}$$

The clogging of emitters is a major problem encountered in drip irrigation systems; as it can reduces application uniformity. To simulate clogging, DripNet uses a random distribution of the clogged emitters based on a given plugging percentage (***Plugging %*** text box). The hypothesis used in this model is that emitters are completely plugged and consequently partial plugging are not taken into consideration.

Grouping of emitters is necessary for performance evaluation of the drip network when 2 or more emitters per plant are used. By default, DripNet uses evaluation on a single emitter, but if the user wants to evaluate his system using a grouping of emitters, he must select the ***Grouping of emitters*** radio button to enable the grouping of emitters text box and insert the number of the group of emitters.

1.d- Pump /Hydrant

Pump or hydrant characteristic curve describes the relation between flow rate and pressure head of the device. These are normally described and illustrated in the manufacturer catalogue as performance curves.

In this page, the water source supplying the drip network could be one of the three options:

- ***Hydrant with flow limiter***
- ***Pump/hydrant without flow limiter***
- ***Reservoir Elevation (m)***: in that case we have an upstream working pressure fixed to the reservoir elevation (Fed by gravity)

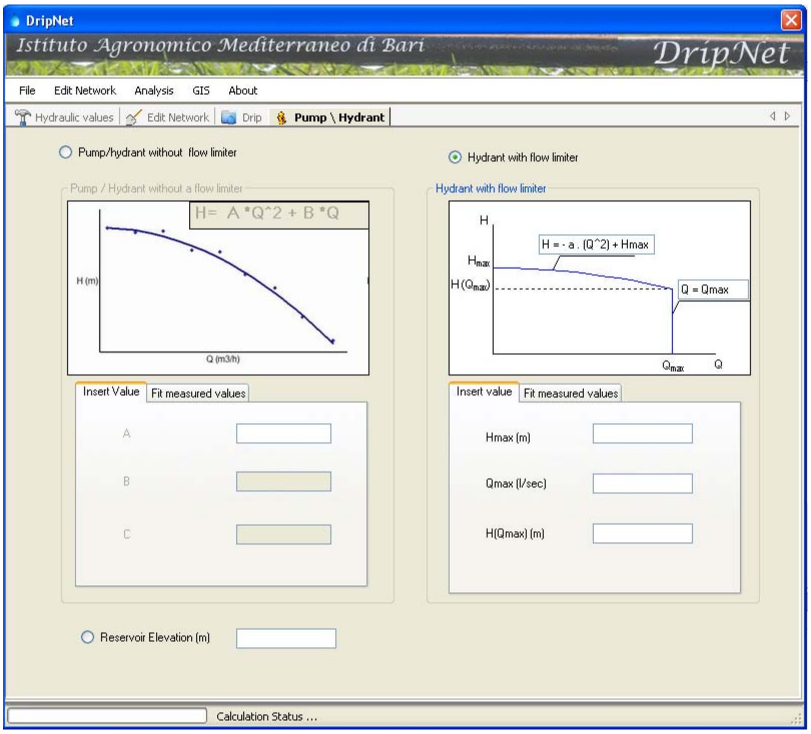


Figure 7: Pump/hydrant characteristics page within DripNet Software

The presence of the flow regulator within a hydrant solves the problem of the flow variation resulted from pressure changing by regulating the cross section of the outlet. At high pressure, the restriction of the outlet cross section increases the head losses and consequently maintains the discharge almost equal to the hydrant nominal discharge (Q_n).

These head losses are insignificant at low pressures as seen in figure 7. However, the flow limiter has some flexibility in delivery, such that maximal discharge *(Q_{max})* is usually around 15% above the nominal discharge Q_n (Totaro M., 2001).

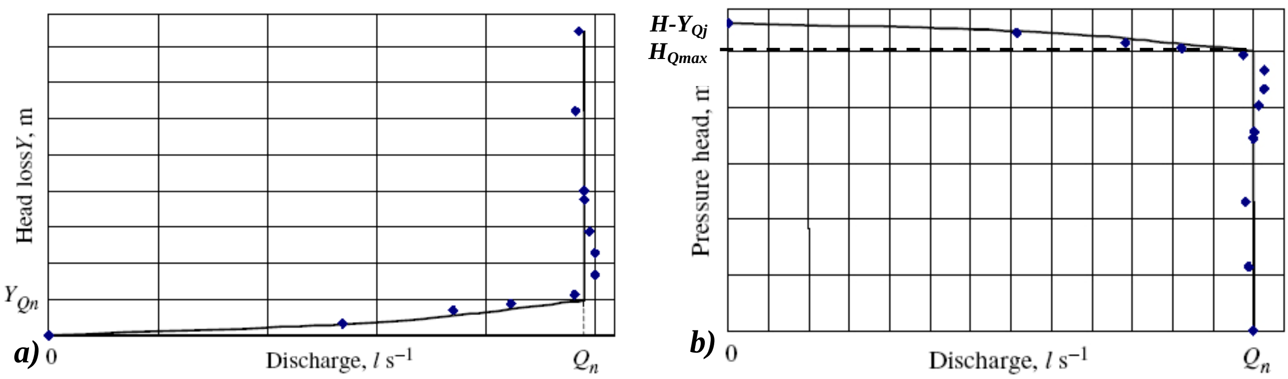


Figure 8: a) Head losses induced by the hydrant flow regulator b) Hydrant characteristic curve

The equation that fit the hydrant characteristic curve (Fig.7.b) is (Lamaddalena N., 1997):

$$Q = \xi_h \sqrt{H} \qquad \text{if} \qquad H_{(Qmax)} < H < H_{max} \qquad (8)$$

$$Q = Q_n \qquad \text{if} \qquad H > H_{(Qmax)} \qquad (9)$$

Where

- Q : Hydrant discharge ($l.s^{-1}$)
- H : Hydrant pressure head (m)
- H_{max}: Upstream hydrant pressure head *(m)*
- $H_{(Qmax)}$: Pressure head corresponding to the maximum or nominal discharge (m)
- ξ_h : Shape coefficient depending on the hydrant characteristics.

The values of ***H**max*, ***Q**max* and ***H**Qmax* could be assigned directly in the ***Insert value*** tab page of the ***Hydrant with flow limiter*** group box or could be obtained from the pair points of hydrant pressure head-discharge inserted in the grid box of the ***Fit measured values*** tab page using the add row and remove row buttons.

In the absence of flow regulator, the hydrant characteristic curve is expressed as pump characteristic curve and presented as a second order polynomial:

$$h_P = AQ^2 + BQ + C \qquad (10)$$

Where A,B and C are constants that can be determined by means of three (h_P, Q) data pairs that bracket the expected range of operation of the pump.
To obtain these coefficients, we write three equations by substituting each data pair into the polynomial to obtain:

$$AQ_1^2 + BQ_1 + C = h_{P1} \qquad (11)$$

$$AQ_2^2 + BQ_2 + C = h_{P2} \qquad (12)$$

$$AQ_3^2 + BQ_3 + C = h_{P3} \qquad (13)$$

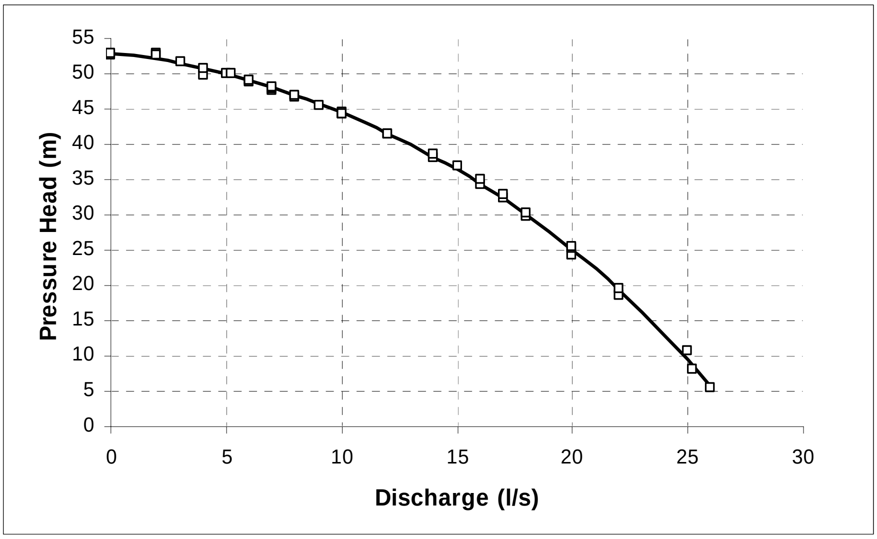


Figure 9: Typical example of a pump characteristic curve

In matrix notation it is represented as:

$$\begin{bmatrix} Q_1^2 & Q_1 & 1 \\ Q_2^2 & Q_2 & 1 \\ Q_3^2 & Q_3 & 1 \end{bmatrix} \begin{Bmatrix} A \\ B \\ C \end{Bmatrix} = \begin{Bmatrix} h_{P1} \\ h_{P2} \\ h_{P3} \end{Bmatrix} \tag{14}$$

To solve this matrix, Lagrangian interpolation was used, where:

$$h_P = \frac{(Q-Q_2)(Q-Q_3)}{(Q_1-Q_2)(Q_1-Q_3)} h_{P1} + \frac{(Q-Q_1)(Q-Q_3)}{(Q_2-Q_1)(Q_2-Q_3)} h_{P2} + \frac{(Q-Q_1)(Q-Q_2)}{(Q_3-Q_1)(Q_3-Q_2)} h_{P3} \tag{15}$$

The head *(h_P)* is again expressed as a quadratic equation in Q, but the terms are rearranged from the earlier approach. The coefficient *A, B* and *C* can be found by expanding the numerators as:

$$c_1 = h_{P1} / (Q_1-Q_2)(Q_1-Q_3) \tag{16}$$

$$c_2 = h_{P2} / (Q_2-Q_1)(Q_2-Q_3) \tag{17}$$

$$c_3 = h_{P3} / (Q_3-Q_1)(Q_3-Q_2) \tag{18}$$

Therefore

$$A = c_1 + c_2 + c_3 \tag{19}$$

$$B = -2[(Q_2+Q_3)c_1+(Q_3+Q_1)c_2(Q_1+Q_2)c_3] \tag{20}$$

$$C = Q_2Q_3c_1 + Q_3Q_1c_2 + Q_1Q_2c_3 \tag{21}$$

The values of ***A, B*** and ***C*** could be assigned directly in the ***Insert value*** tab page of the ***Pump / Hydrant without flow limiter*** group box or could be obtained from the pair points of hydrant pressure head-discharge inserted in the grid box of the ***Fit measured values*** tab page using the add row and remove row buttons.

2- Network Solution

2.a- Network Characteristic Curve

Starting from a given low pressure head at the most downstream emitter ($H_{1,1}$)of the lateral, the head losses in the pipes network are calculated upward till reaching the upstream end of the lateral. Thus, the obtained pair of pressure-discharge constitutes the first point of the lateral characteristic curve.

The same procedure will be conducted but this time with a pressure head at the downstream emitter of the lateral slightly increased respect to the one used in the previous iteration ($H_{1,i+1} = H_{1,i} + \Delta H$) and consequently another point on the lateral curve will be obtained. The iterations will continue with a gradual increase of the downstream pressure head (ΔH) until enough points to fit the lateral characteristic curve are obtained. The lateral characteristic equation will have the following form:

$$QL = K_L HL^{X_L} \tag{22}$$

Where:

QL : Discharge at the upstream end of the lateral ($m^3.h^{-1}$)

HL : Pressure head at the upstream end of the lateral (m)

K_L and X_L: parameters depending on the lateral hydraulic characteristics and on the land topography.

The pressure head of emitter K at iteration i is obtained using the following equation:

$$H_{k,i} = \left(\sum_{ii=1}^{K-1} \left(H_{ii,i} + Y_{ii,i} + hL_{ii,i} \right) \right) + \left(Z_1 - Z_K \right) \qquad \text{With} \quad K \neq 1 \tag{23}$$

Where:

$H_{k,i}$: Pressure head corresponding to emitter k and iteration i (m)

Z_K : Elevation head at the dripper k (m.a.s.l.)

ii: index of the pipe located upstream the emitter K

$Y_{ii,i}$: Head losses (Darcy-Weisbach) within the pipe ii of the iteration i (m)

$hL_{ii,i}$: Local loss within the pipe ii of the iteration i (m)

$$hL_{ii,i} = K_{Loss\ ii,i} \frac{V_{ii,i}^{2}}{2g} \tag{24}$$

Where

$K_{Loss\ ii,i}$: Local loss coefficient depend on the nature of local resistance within the pipe ii

$V_{ii,i}$: downstream mean velocity within the pipe ii of the iteration i *(m.s^{-1})*

g : gravity acceleration *(m.s^{-2})*

$$Y_{ii,i} = f \frac{L_{ii}}{D_{ii}} \frac{\left(\sum_{jj=1}^{K} Q_{jj,i} \right)^{2}}{2gA_{ii}^{2}} \tag{25}$$

Where:

L_{ii} : Length of pipe ii corresponding to the upstream reach of dripper ii (m)

D_{ii} : Diameter of pipe ii (m)

A_{ii} : Cross sectional area of pipe ii (m^2)

$Q_{jj,i}$: Flow Discharge of emitter jj, at iteration i ($m^3.h^{-1}$)

f: Friction factor depends on Reynolds number *(Re)* and on the relative roughness of the pipe

Once the characteristic curve of each lateral of the network is obtained, the head losses calculation from the downstream end of the manifold, with a low pressure head at the most downstream lateral, upward till reaching the hydrant will reveal the first point of the network curve. A new iteration with a slight pressure increment at the downstream lateral will add another point on the network curve. The iteration will continue until enough points to plot the characteristic curve of the network are obtained. Finally, the equation that fit the network characteristic curve is as following:

$$Qm = K_m Hm^{X_m} \tag{26}$$

Where:

Qm : Discharge at the upstream end of the network ($m^3.h^{-1}$)

Hm : Pressure head at the upstream end of the network (m)
K_m and X_m: parameters depending on the network hydraulic characteristic and on the field topography

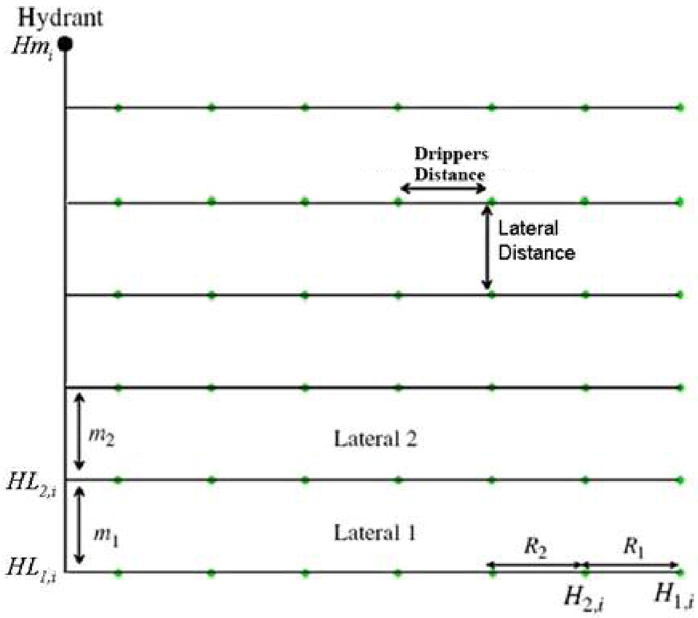


Figure 10: Network enumeration as used by the model to generate the network characteristic curve

2.b- Solve Network using DripNet

Once you enter all the data of the different components of the drip irrigation system as previously described, you can solve the network by clicking from the main menu on ***Analysis*** >> ***Solve Network*** >> ***Run.*** Three additional pages will be added on the main form showing the results obtained from running this operation.
Network/Pump curve page will reveal the effective operating pressure and discharge of the network by generating and relating the network characteristic curve with the pump/hydrant curve as seen in figure 10. The k and x text boxes at the bottom of the page represent the parameters of the network characteristic curve equation that link the discharge with the pressure head as following:

$$Q = KH^x \tag{27}$$

Where:
Q: Network upstream discharge ($l.s^{-1}$)
H: Network upstream pressure head (m)
K and x : parameters depend on the topographic elevations, hydraulic characteristics and drip network components.

Use the copy and save buttons to copy or save the graph of the interface between the network and hydrant/pump characteristic curve

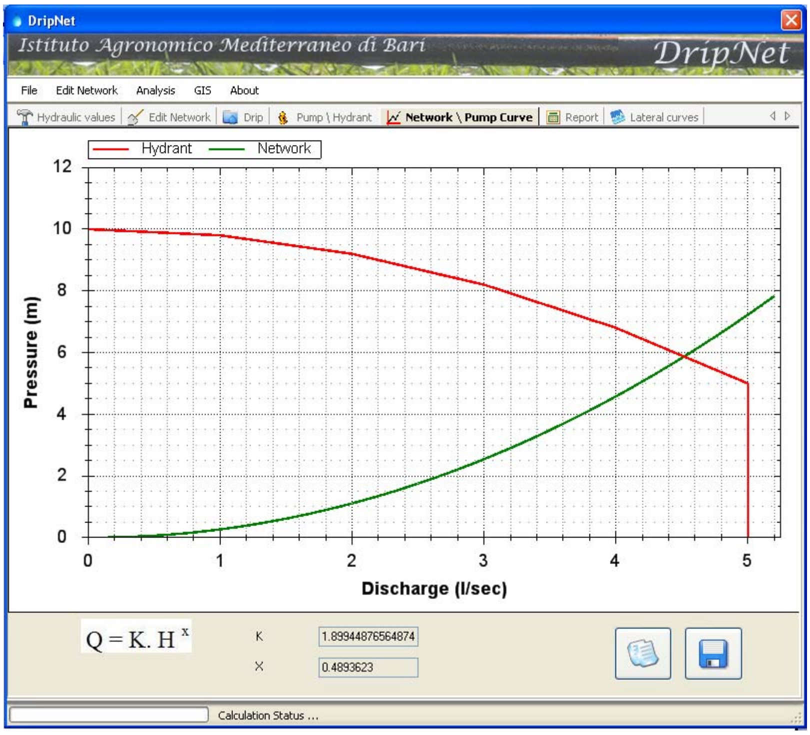


Figure 11: Network and hydrant characteristic curve as generated by DripNet software

In the ***Report*** Page the simulated working pressure (m) and discharge ($l.h^{-1}$) for each single emitter of the network are presented in a table that could be exported into an excel table by just clicking on the export table button. In the working parameters group box, the values of the upstream working pressure head and discharge of the drip network, obtained by interfacing the network with the hydrant or pump characteristic curve, are presented (Fig.12).

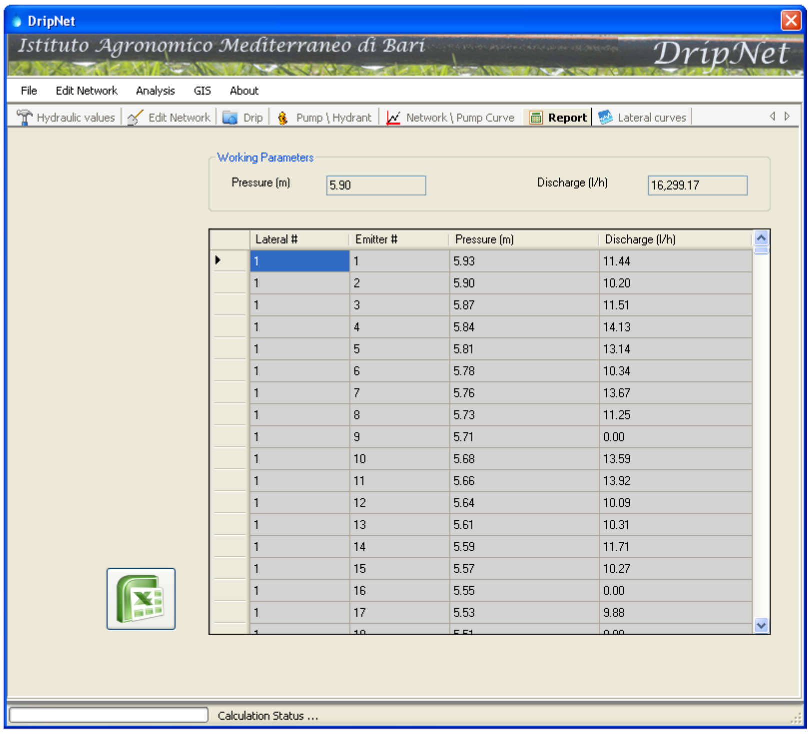


Figure 12: Working Pressure and discharge of each single emitter of the network as simulated by DripNet software

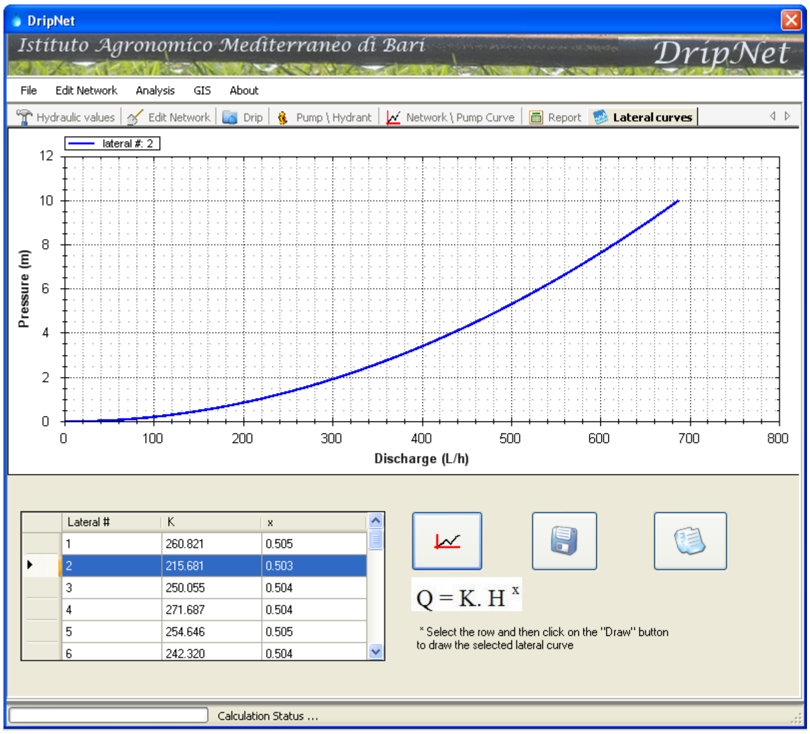


Figure 13: Lateral characteristic curves of the drip network as generated by DripNet software

k and *x* parameters of the laterals characteristic curves equations ($Q=K.H^x$) are presented in the data grid of the ***lateral curves*** page (Fig.13). Select the row that corresponds to the lateral that you would like to draw its characteristic curve and by clicking on the draw button, the appropriate lateral curve will be obtained. Use save as and copy buttons in order to save the figure or copy it to be pasted later on.

After network have been solved, the layout of the network and the emitters position as well as their characteristics could be saved as shape file by selecting ***Analysis >> Solve Network>> Save Shapefiles>> Pipes*** and ***Analysis >> Solve Network>> Save Shapefiles>> Emitters*** respectively. These shapefiles could be saved and used later under the GIS section.

3- Performance Analysis

Once the network is solved as explained in the previous paragraph, the performance of the drip network could be evaluated by clicking from the main menu on ***Analysis >> Analyse Performance>> Run.*** At the end of calculation process, a new page named ***Uniformity*** will be added showing the emission uniformity of the drippers ***EU***, the pressure uniformity ***Up***, minimum net depth of applied water and the relative depth of application ratio at different percentage of adequately irrigated area (Fig.14).

Merriam et al.(1973) developed one of the first field evaluation techniques for drip irrigation systems. The Emission Uniformity (EU) was calculated and adjusted to the number of emitters per plant (*n*) using the following formula:

$$\boldsymbol{E}U = \left(1 - \frac{1}{\sqrt{n}} + \frac{1}{\sqrt{n}} * \frac{q_{min \quad lq}}{q_{avg}} \right) x \quad 100 \tag{28}$$

Where:

$q_{min \quad lq}$: average of the lowest one-quarter of the drippers flow rates

q_{avg} : average of the total drippers flow rates

Bleisner (1977) recognized that pressures must be adjusted by the emitter discharge exponent found in the emitter pressure-discharge equation (Eq.1). For that reason, he introduced the concept of pressure uniformity (U_p) which was eventually used as:

$$\boldsymbol{U_P} = \left(\frac{\overline{P}_{25}}{\overline{P}} \right)^x \tag{29}$$

$\overline{P}_{25}$: average of the lowest one-quarter of the drippers pressure

$\overline{P}$: average of the total drippers pressure

x: emitter discharge exponent found in the emitter pressure-discharge equation

The water distribution efficiency *(DE)* described by Keller and Bleisner (Keller and Bleisner, 2000) is used to give more useful meaning to the concept of uniformity. It is expressed as:

$$DE_{pa} = \frac{Minimum \quad net \quad depth \quad received \;\; by \quad wettest \quad pa\% \quad of\; area}{Average \quad net \quad depth \quad received \quad over \quad entire \quad area} \tag{30}$$

Where:

pa percentage of adequately irrigated area, *%*

DE_{pa} distribution efficiency for the desired percentage adequacy, *%*

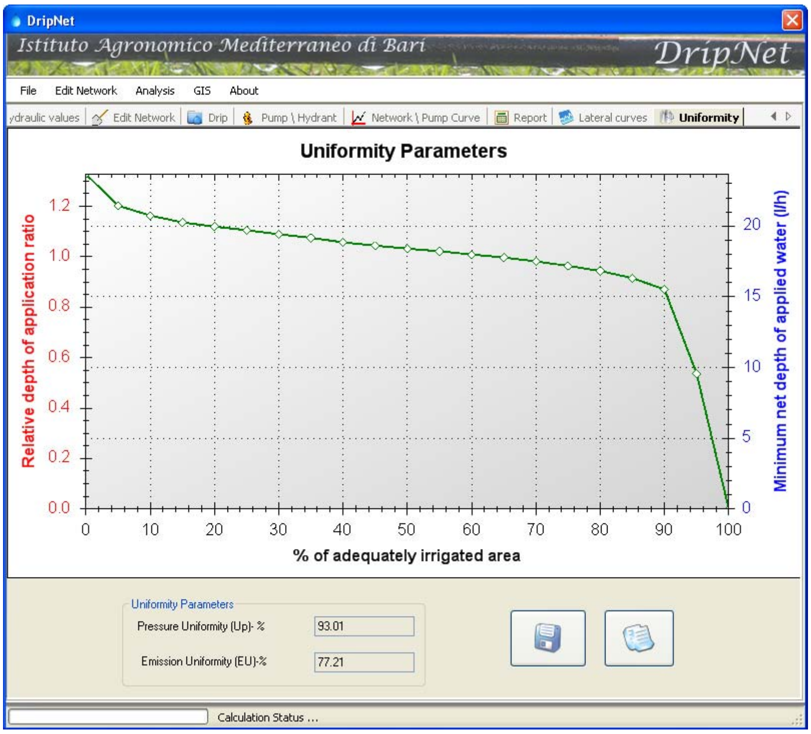


Figure 14: Uniformity parameters obtained from analyzing the performance of a drip network using DripNet software

The user can use the save as and copy buttons in order to save the uniformity chart or copy it in order to be pasted later on.

4-Dynamic Analysis

Pressurized water distribution systems with on-demand delivery schedule together with drip on-farm irrigation networks could be considered one of the major solutions for the future water challenge in agriculture sector as they can provide better services, higher performance and elevated efficiencies respect to the traditional channel and surface irrigation systems.
The main problem of the on-demand water distribution systems is the variation of the discharges flowing inside the pipes. Such discharges strongly vary over time depending on the cropping pattern, farmer’s behavior and meteorological conditions causing a high fluctuations in the hydrant pressure head.

DripNet computes and analyze the performance of the drip network under variable hydrant pressure head condition. By selecting from the main menu ***Edit Network << Dynamic Analysis*** beside the 4 input pages a new page called ***Dynamic Analysis*** is added on the main form.
Fill the ***Hydraulic values***, ***Edit Network*** and ***Drip*** pages as previously explained to describe the hydraulic components and layout of the drip network. In the ***Pump/Hydrant*** page only ***Hydrant with flow limiter*** will be enabled. Fill the data required to draw the hydrant characteristic curve at a given upstream hydrant pressure head.

In the data grid table of the ***Dynamic Analysis*** page add different time steps (minutes) by clicking add row button, where each time step corresponds to a given working upstream hydrant pressure head. Once the variation of the hydrant pressure head and its operating time is defined, you can run the dynamic analysis by selecting ***Analysis >> Solve Network >> Run*** or ***Analysis >> Analyse***

Performance>> Run. Select or create a new folder in which the results will be saved in as ***Report.txt***. The results for each time step will also be added and revealed in the ***Dynamic Analysis*** page in terms of pressure head and discharge of each single emitter. In the table located at the bottom of the page, the effective working parameters of the network (Pressure and Discharge) for each time step are demonstrated together with ***EU***, ***Up***, relative depth of application ratio ***DE*** and minimum net depth of applied ratio ***dn*** at different adequately irrigated area (10, 50 and 90%).

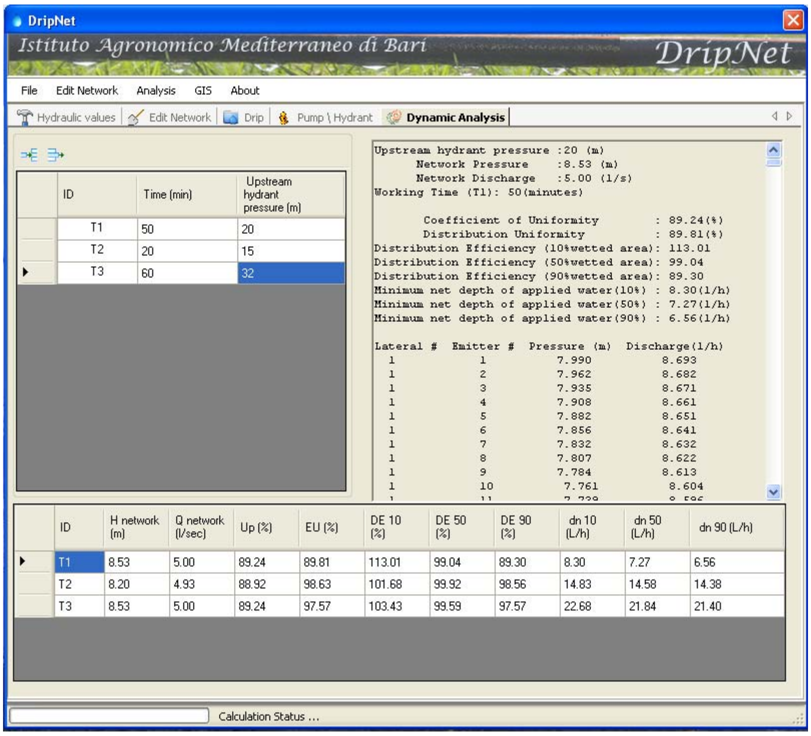


Figure 15: Results of the dynamic analysis of a drip network using DripNet software

5- Using GIS

As previously mentioned, Dripnet software have the ability to save the pipe network layout and emitters working parameters as shape files ".shp". To access on the internal GIS of DripNet software select the ***GIS*** from the main menu. A new GIS page will appear with a tool box showing the following items (fig18):

- Add layer button : allows you to add a shape file ".shp" or a raster file ".asc".
- Remove layer button : allows you to remove a selected layer from the GIS page.
- Identifier button : allows you to identify the value of the selected layer by clicking on the on the map. The values will be shown in the text box located at the bottom left of the window form.
- Zoom in , Zoom out and Zoom to extent and Pan buttons could be used to change the visualization of the maps.

To change the symbology of the loaded layers, select first the appropriate layer. Then right click on the map legend, select ***Palette*** and a ***Shape Palette*** will appear (Fig.18).
In the ***layer name*** drop down list select the name of your shape layer. Select the field to be classified and the type of legend to be used and the color from the appropriate drop down lists. Click Ok to apply changes.

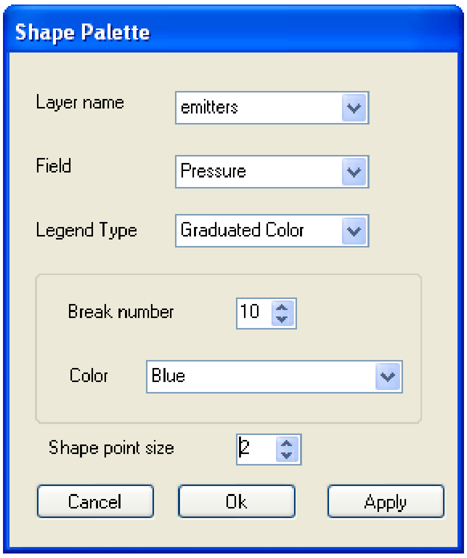


Figure 16: Symbology palettes of a shape file as presented in DripNet Software

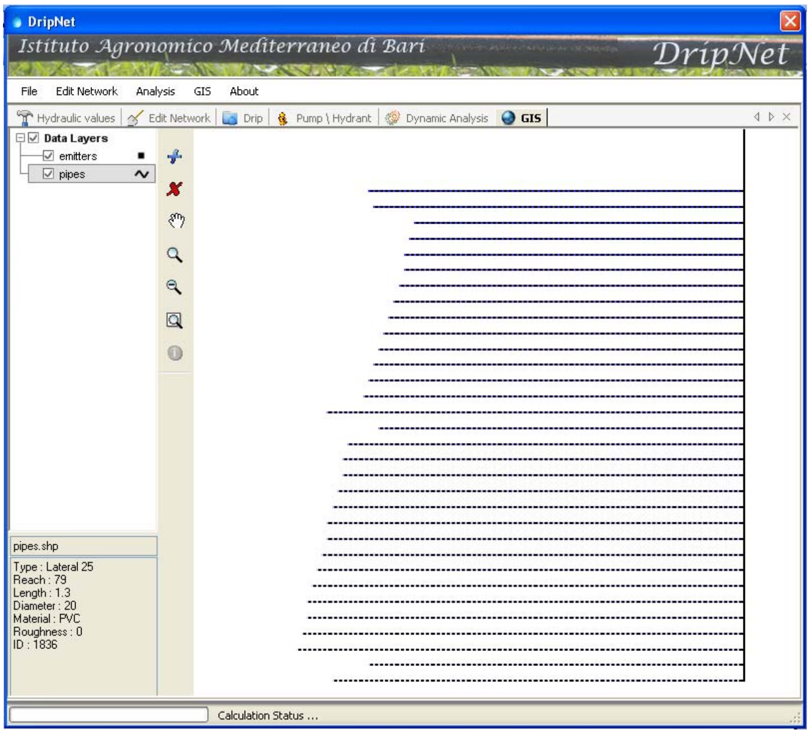


Figure 17 : An example of the graphical presentation of the results using DripNet software

6-References

BLEISNER R.D., 1977. Field evaluation of trickle irrigation efficiency. *Proceedings of the ASCE*

Keller J. and Bleisner R.D., 2000. Sprinkler and trickle irrigation.Van Nostrand Reinhold- New York.

LAMADDALENA N.,1997. Criteri di individuazione degli stati di crisi in una rete irrigua. *Atti del convegno di studio su: Uso del suolo e delle acque*. Ancona, Italia. P69-77.

MERRIAM J.L., KELLER J. AND ALFARO, J.F. 1973. Irrigation Systems Evaluation and Improvement. *Agricultural and Irrigation Engineering Department*, Utah State University, Logan, UT.

PAI WU, 1996.An assessment of hydraulic design of micro-irrigation systems. *Agricultural water management* 32(1997) 275-284.

TOTARO M., 2001. Analisi sperimentale del ruolo degli idranti sull'efficienza delle reti irrigue. Tesi di laurea in costruzioni idrauliche, Politecnico di Bari, Facolta di ingeneria.