Increasing actual drip irrigation performance by system design and maintenance. The potencial of Ve. Pro. L. G. s 2008 support tool.

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Introduction

High efficiency of irrigation water use and low environmental impact are goals leading sustainable on-farm irrigation towards the next future. Such objectives can be achieved in different ways, depending on site-specific agronomical and economical conditions (i.e., crop type, farm size, soil characteristics and homogeneity, public financial aid to modern irrigation systems, etc.), role of technical support agencies and farmers' awareness on resource protection.

Moreover, user's attitude in the market of irrigation facilities is relevant to the final result. Due to the widespread lack of technical and technological knowledge, decisions are often taken on the basis of external suggestions or according to a cost-based approach (i.e., selection of the cheapest device). Poor knowledge about the characteristics of equipments available in the market may increase farmers' indecision and damage their bargaining power with the seller. Future cost and performance uncertainty may limit willingness to improve irrigation systems. Sustainability will be affected as a result.

Poor attention is given to water and energy saving and micro-irrigation is not used at its best in many cases. Inappropriate system design, scarce maintenance, use exceeding the suggested lifetime and inaccurate scheduling are a widespread reality even in advanced Countries.

Whatever the solution may be, farmer's role is always crucial, since overall irrigation efficiency is the result of technological choices and technical skills. Managing each agro-environmental system, chances of positive outcomes depends on the way the irrigation system is conceived, devised, checked and repaired, in order to cope with the soil-plant-climate dynamics. That is, consciousness should guide irrigated agriculture in equipment selection, system design, setting operating conditions and managing maintenance operations.
Based on such assumptions, this paper aims to appraise the contribution of the software Ve.Pro.L.G.s 2008 (Figure 1) in both design and test of drip systems.

Figure 1 - Ve.Pro.L.G.s 2008 logo.

1. The software

Ve.Pro.L.G.s 2008[1] (Bertolacci et al, 2008) is a user-friendly application software, created by the Laboratorio Nazionale dell'Irrigazione (LNI) of Pisa (Italy), in order to help users in finding suitable technical and economical solutions (equipment choice, system design and test, water and energy use, etc.) in a given farm context.

The software has two main objectives:

- support the performance evaluation of existing drip systems, in terms of water and energy use. Entering the model of the drip line together with some basic field characteristics, namely ground slopes, row length and working pressure, the software provides information concerning the best performance achievable under optimal conditions (good system maintenance). Minimum, maximum, average discharge per meter of drip line, coefficient of emission uniformity (EU) and distribution efficiency are provided as well.
- support the design of a drip system in actual farm context, to achieve targeted (set of) performance in terms of water and energy use. With the same inputs, the model provides a number of information, such as:
  - with reference to a selected drip line, the pressure to apply at lateral inlet to maximize the EU or, optionally, to minimize energy consumption;
  - with reference to a selected drip line, the maximum allowable length of the lateral to achieve a required degree of uniformity;
  - the ranking of drip lines in terms of EU, under the same working conditions.

Both for designing and testing, it is possible to:

-screen the drip lines stored up in the data base, according to the crop type (floriculture, nursery, perennial and annual) and some technical characteristics, such as external pipe diameter, pressure compensating (PC) emitters, etc.;
-consider the influence of manifold and lateral slopes;
-describe the line discharge in litres/meter*hour or litres/dripper:
-assess irrigation performance when splitting the existing laterals into two shorter laterals, using one paired manifold or two single manifolds.

[1] *Verifica e Progettazione di Linee Gocciolanti e settori*

Technical and economical evaluation is allowed by entering data on field dimensions and slopes, crop spacing, laterals and emitters spacing, expected seasonal water supply, manifold type, unit cost of power and fuel, cost and lifetime of a given drip line.
Supposing correct maintenance and proper water filtration, the way an existing system should work can be reconstructed. The value of the following parameters is supplied as output:

-estimated EU (%);
-energy required for water distribution (Wh/m^3);
-min, max, average discharge (l/h*m or l/h*emitter);
-discharge of the low quarter (l/h*m or l/h*emitter);
-min, max, average pressure (m);
-average irrigation rate (mm/h);
-irrigation rate of the low quarter (mm/h);
-seasonal water loss (%, m^3/ha; m^3/yr);
-seasonal energy consumption (kWh or kWh/ha);
-influence of the drip line cost (€/yr or €/ha);
-annual power cost (€ or €/ha), either for electric or motor pumps.

Outputs can be managed to improve actual performance, according to the specific working conditions and the need for water and energy saving. Taking into account the basic system data and the options set in the input window (Figure 2), values of the following operating parameters are given:

-pressure (m) to be applied at the manifold or lateral inlet to minimize energy consumption or maximize EU;
-maximal length of the lateral matching the targeted EU;
-ranking of the best drip lines in terms of EU (*irrigation efficiency*) or energy use (*energetic efficiency*);
-performance achievable by splitting the laterals by means of a paired manifold or two opposite manifolds;
-the correct positioning of a paired manifold when working in sloping fields (length of the laterals operating upward and downward).

Test and design can simulate the operating conditions of single drip lines affected by up to three different ground slopes along the lateral and one ground slope along the manifold. Reconstruction of drip line functioning is also possible on systems supplying both wide-spaced trees and nursery containers.

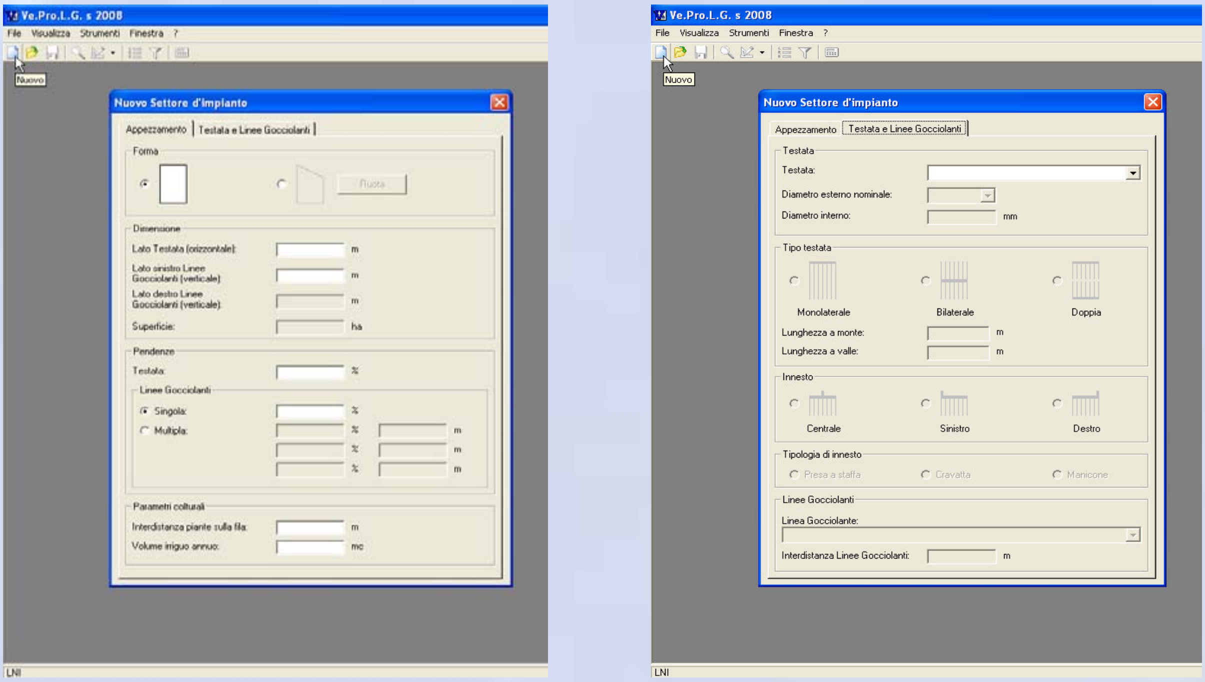

Figure 2 – Ve.Pro.L.G.s 2008 input window

The software was used during field investigations carried out in farms located in four irrigated areas of Central Italy, characterized by both sub-humid and semi-arid climate, representative of irrigated annual and perennial crops.

2. Case study on perennial crop

An apple orchard, located in inland Tuscany, central Italy, is drip irrigated by Poly Ethylene Low Density (PELD) laterals Ø 20 mm, running downward along a 4% slope (Figure 3). Row length varies from 100 to 130 m, PC emitters are spaced 0.75 m along the line, nominal discharge is 4 l/h, operating pressure is 200 kPa. Farmer schedules irrigation on "feeling" basis, without any on-farm and external support.

Figure 3 – The apple orchard

Expected EU, equal to 93.3%, was estimated by the software.
Field evaluations were carried out during year 7 and year 9 (suggested lifetime of the system is 5 years), using the discharge values of 130 emitters measured along the lines (Figure 4).

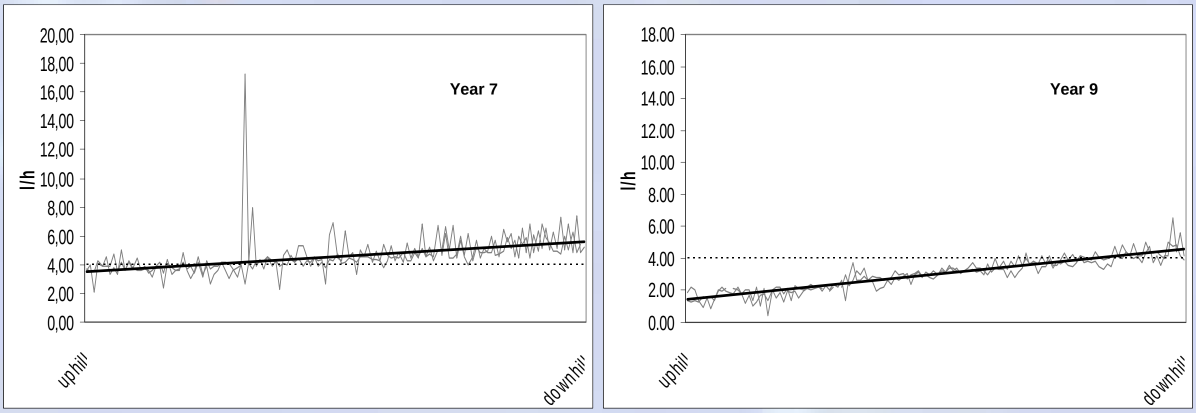

Figure 4 - Emitter discharge along drip lines.

In year 7 and year 9, drippers average discharge was 4.6 l/h and 3.0 l/h, and EU was fallen to 77.6% and 58.0% respectively.

Poor performance can be explained by emitters clogging and loss of pressure compensating capacity, probably related to excessive system lifetime and inappropriate maintenance.
The need for drip system efficiency was supported by the software. Given the field conditions (row length and ground slope), drip line selection was made according to two approaches: EU maximization and EU under a given pressure at the lateral inlet (Figure 5).

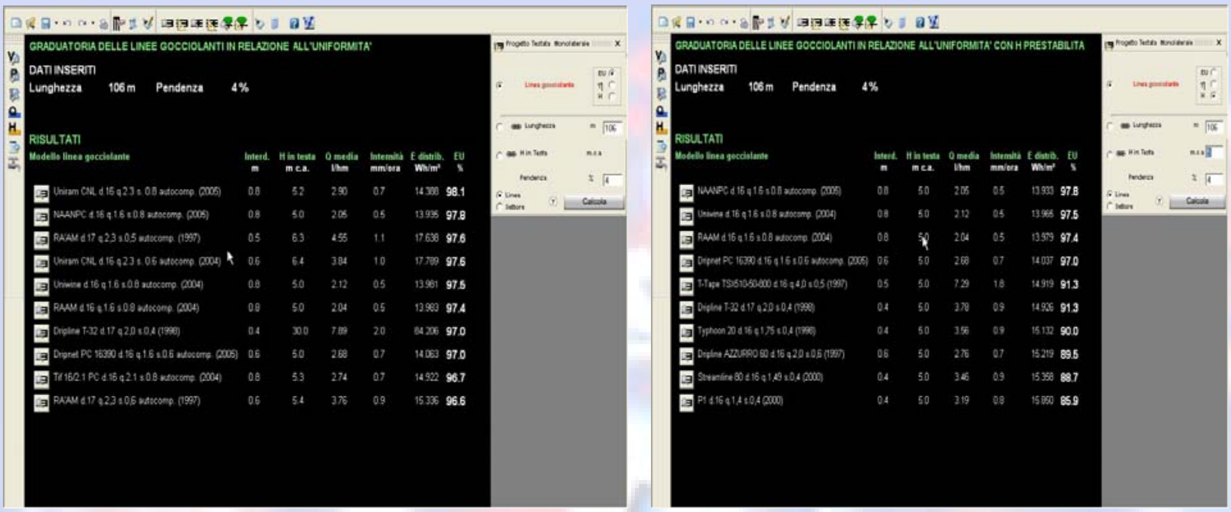

Figure 5 - EU maximization and EU under a given pressure (50 kPa) at the lateral inlet.

a-EU maximization

The best drip lines, both PC and not PC, were selected by the software among those listed in the database and previously tested by the LNI. EU varied from 98.1 to 96.6%. Energy required by the 9 PC lines varies from 13.9 to 17.8 Wh/m^3, the non PC line needs 84 Wh/m^3, due to the higher pressure at the inlet (300 kPa) with respect to the PC lines (from 50 to 64 kPa).

b-Given pressure at lateral inlet

EU ranking under a given pressure (50 kPa) at the lateral inlet was yielded. All the best ten options, from 97.8% to 85.9%, are PC. Energy requirement varies from 13.9 to 15.8 Wh/m^3, savings up to 42% and 60% in year 7 and 9 respectively, allowed by both less water use and operating pressure.

c-Other options

Under the same input data and screening drip lines according to options such as non PC or pipe external diameter, new rankings can be set out.
Moreover, for a given drip line, annual cost of investment and energy can be supplied, provided that line and energy cost is known.

3. Case study on annual crops

A pluriennial field survey was carried out in forty irrigated farms in Tuscany, in order to evaluate the way irrigation practice is carried out. Performance of eleven drip systems were investigated according to the parameter EU (Figure 6). Taking into account the specific characteristics of the method, a reasonable target threshold of EU was set equal to 90% for systems irrigating annual crops.

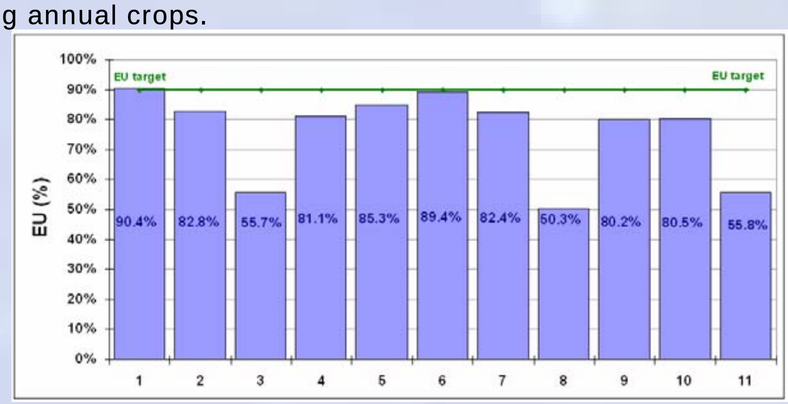

Figure 6 - Measured EU in some drip systems.

Considering the average seasonal water supply (3,221 m^3/ha) and the measured EU values, water saving was estimated assuming systems operating at the target EU (Figure 7).

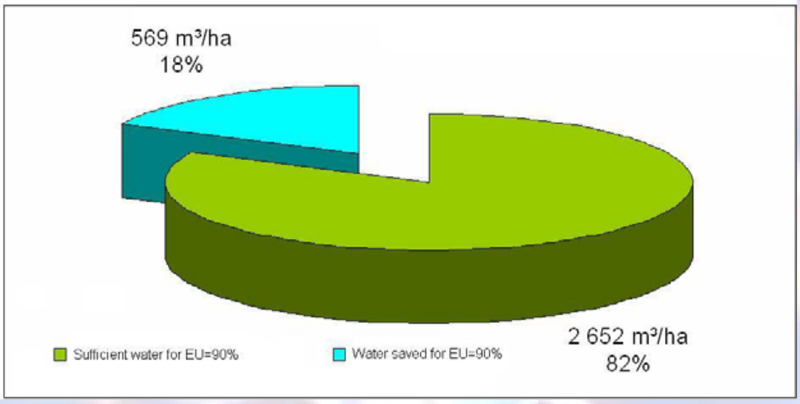

Figure 7 - Seasonal water saving for system EU=90%.

Achieving EU=90%, actual seasonal water saving would be 18%, that is more than 500 m^3/ha under current operating conditions.

Results evaluation by software use

Performance simulation using Ve.Pro.L.G./s 2008, showed that most of systems were well designed. Poor results were due to bad operating conditions and scarce maintenance. Careful system management should save 16% of seasonal water (Figure 8).

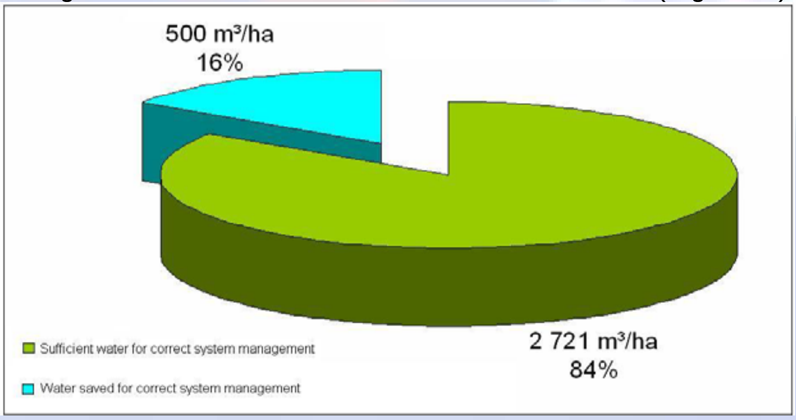

Figure 8 - Water saving allowed by careful system maintenance

4. Conclusions

Drip systems often operate under inefficient conditions, in spite of high potential. General farmers' attitude is to prolong technical lifetime beyond suggested threshold, resulting in poor performance and excessive water and energy use. As a rule, and in the framework of the farm economy, cut maintenance and occasional mending are insufficient to restore proper system use. In most cases, users are not able to reckon actual inefficiency in terms of energy and water, especially where support services are not active. Performance achievable by new and properly designed systems are unknown as well, unless external technical advice is supplied.

Farmer consciousness about the importance of system project and maintenance may produce an important rush towards an advanced approach towards the sustainability of the irrigation practice. This is true when uncertainty on initial and maintenance cost can be scaled down. Ve.Pro.L.G.s 2008 is an effective, user-friendly decision support tool, able to help overcoming hindrances dividing ordinary from improved micro irrigation practice.

Bibliography

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