Irrigation and Drainage Engineering

(Soil Water Regime Management)

(ENV-549, A.Y. 2025-26)

4ETCS, Master option

Prof. Paolo Perona
Platform of Hydraulic Constructions

Lecture 7-2. Micro-irrigation: principles and benefits

Localized irrigation or Micro-Irrigation

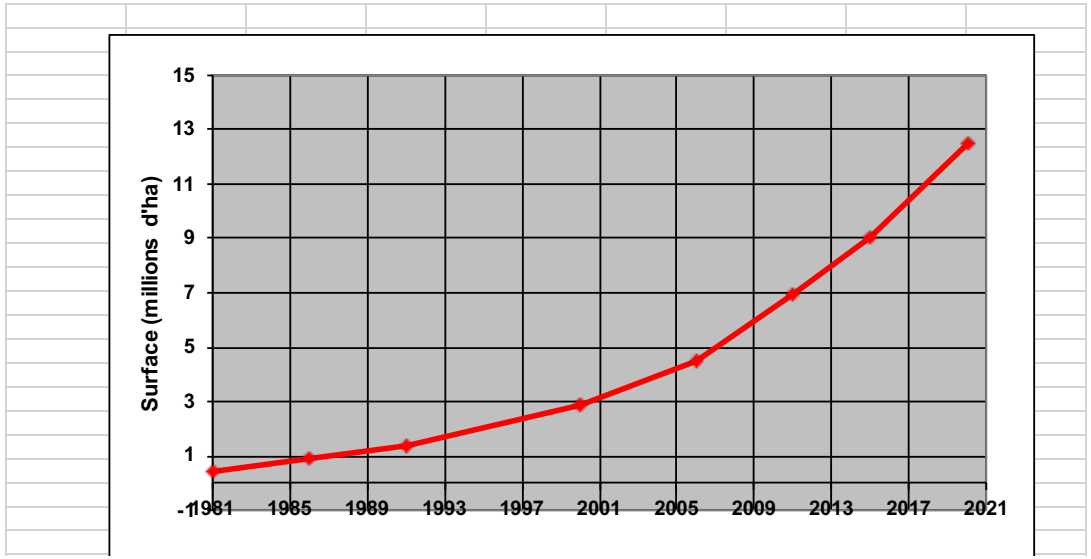
Basic characteristics:

- localised apportion
- low flow
- at frequent intervals

Several techniques :

- line system (Bas-Rhône system)
- mini-diffuser system
- drip system

"...sustainable irrigation must harmoniously balance the concurring water demands for industrial and municipal uses with the requirements of natural ecosystems." (Vico & Porporato, WRR 2010)



Changes in the global surface implementing microirrigation worldwide

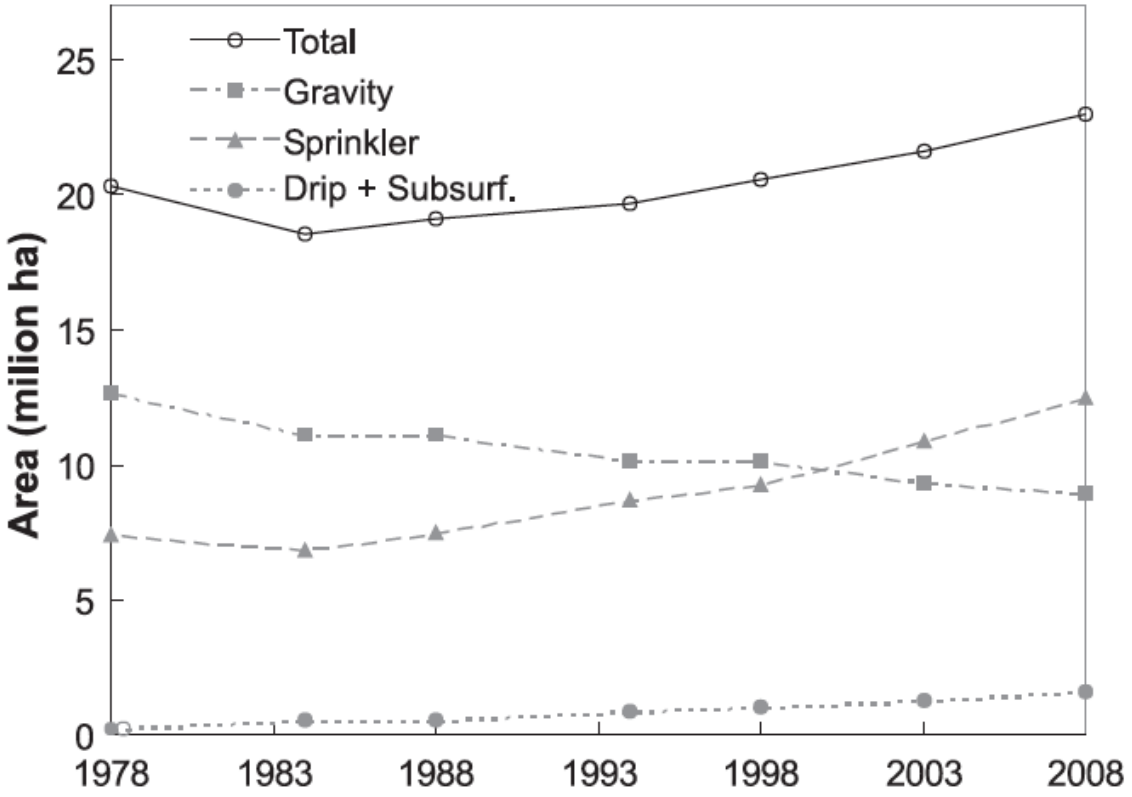


Fig. 2. Changes in irrigated areas by irrigation methods in the USA over the period 1978–2008. Source of data: Table 4 of the US Census of Agriculture, Farm and Ranch Irrigation Survey for the corresponding years. Over the period 1978–1994, reported areas refer to the USA conterminous states only.

After Vico and Porporato, Advances in Water Resources, 2011

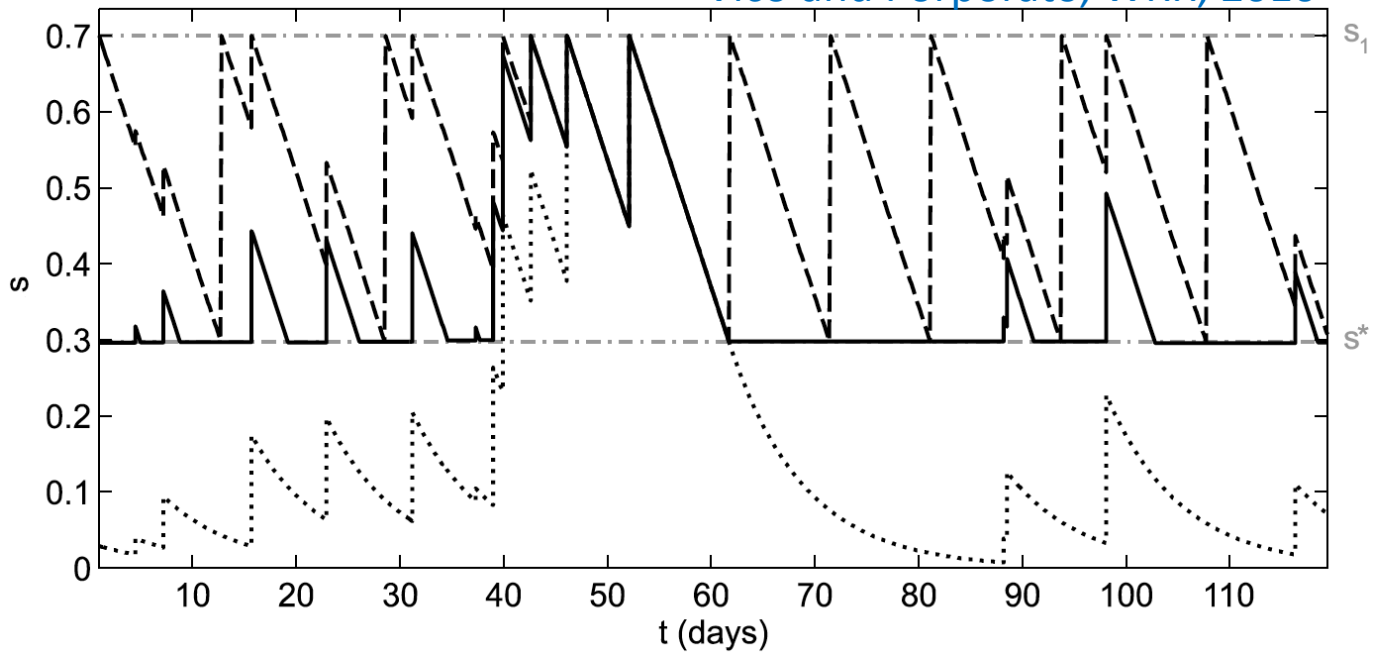
Ecohydrological basis of microirrigation

Concept (stress avoidance irrigation):

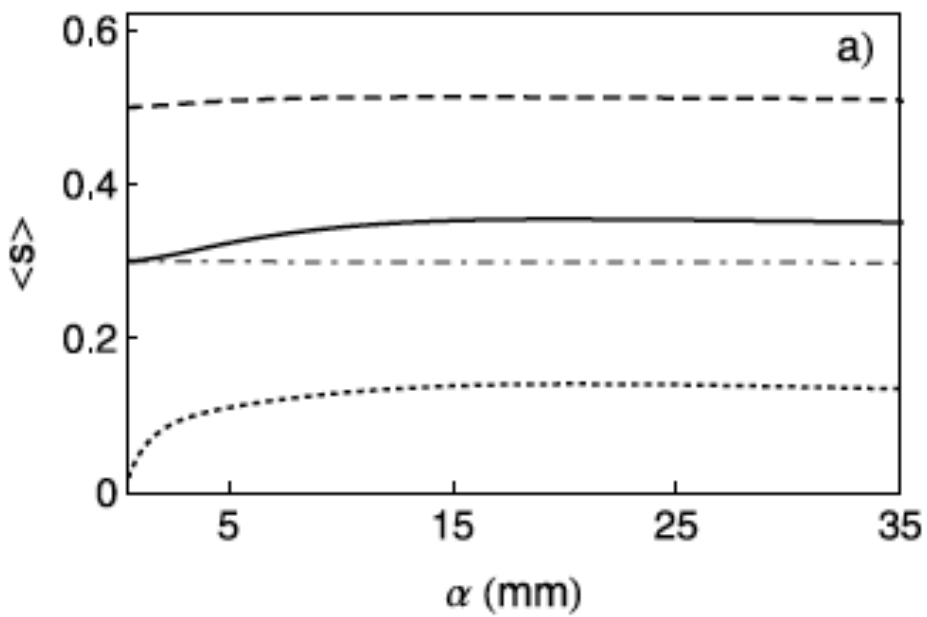
- Maximize crop production (contrary to deficit irrigation)
- Water must be delivered before soil moisture hits the stress level
- Stress level can be associated to that inducing stomatal closure, s*

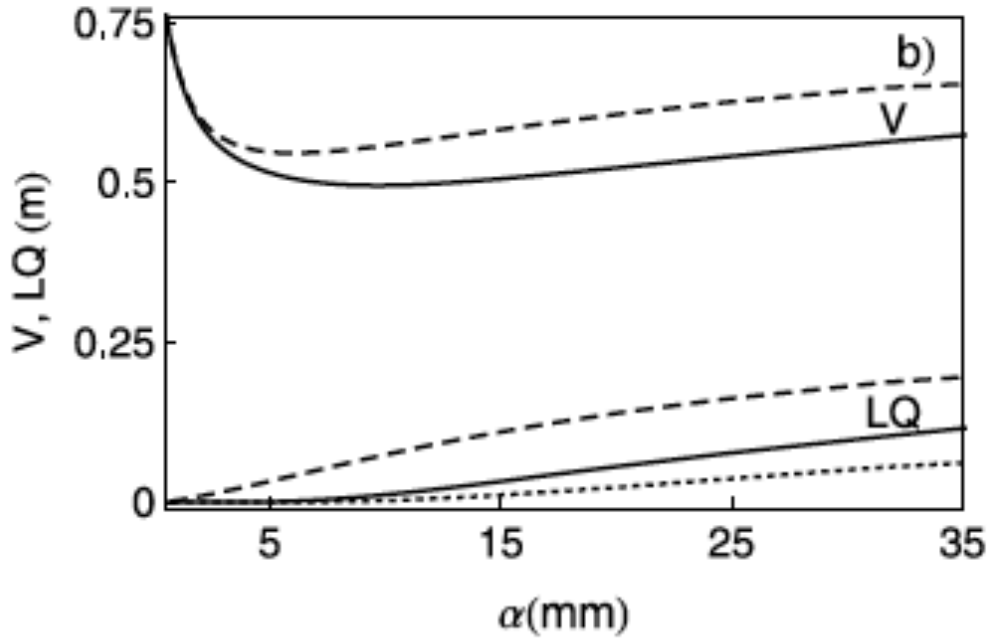
$$nZ_r \frac{ds(t)}{dt} = R(t) + I(s(t)) - ET(s(t)) - LQ(s(t)),$$

Vico and Porporato, WRR, 2010



- Rain fed irrigation, i.e. no artificial irrigation (dotted line)
- Traditional (furrow or flood) irrigation (dashed line)
- Microirrigation (solid line)

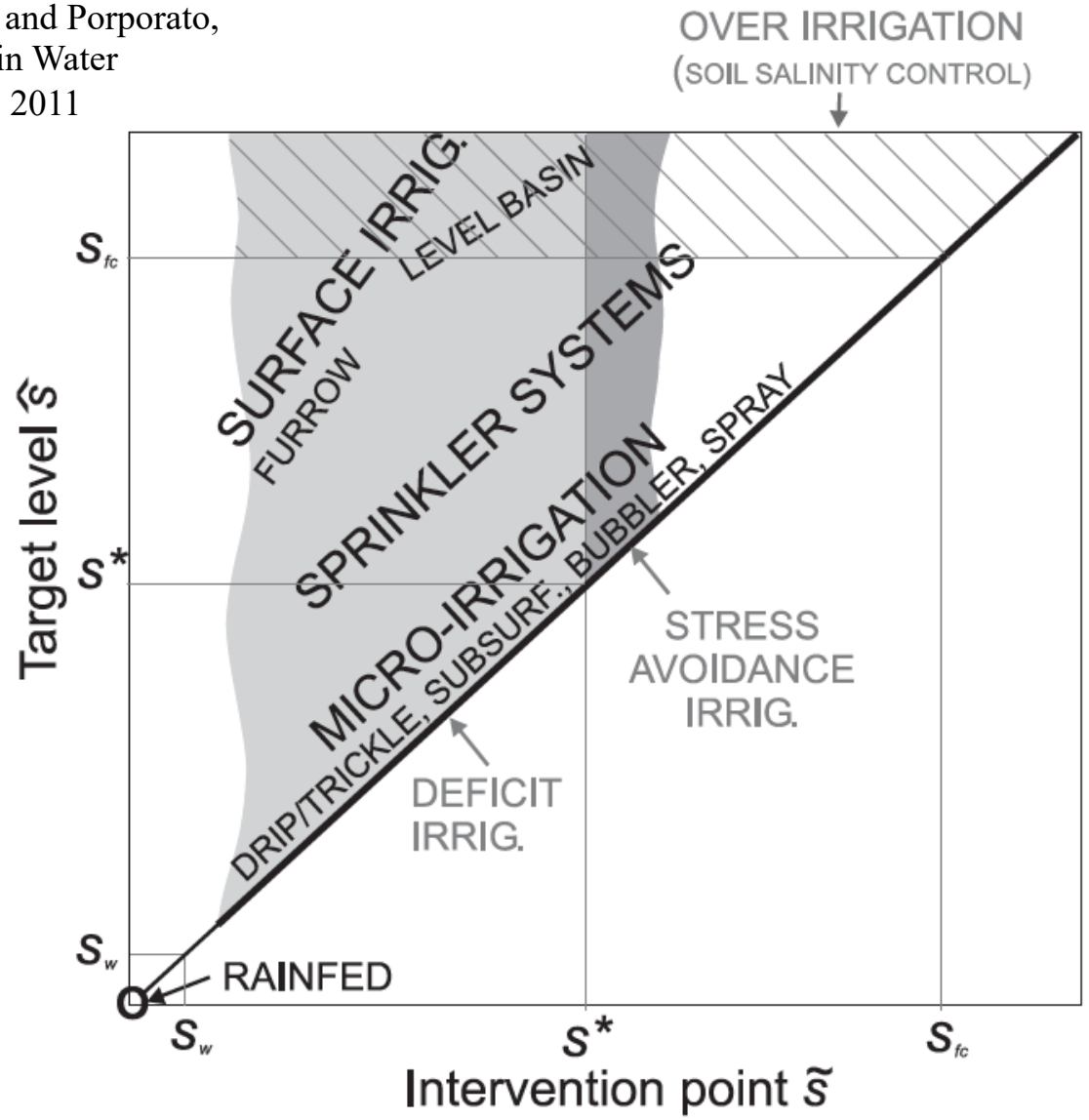


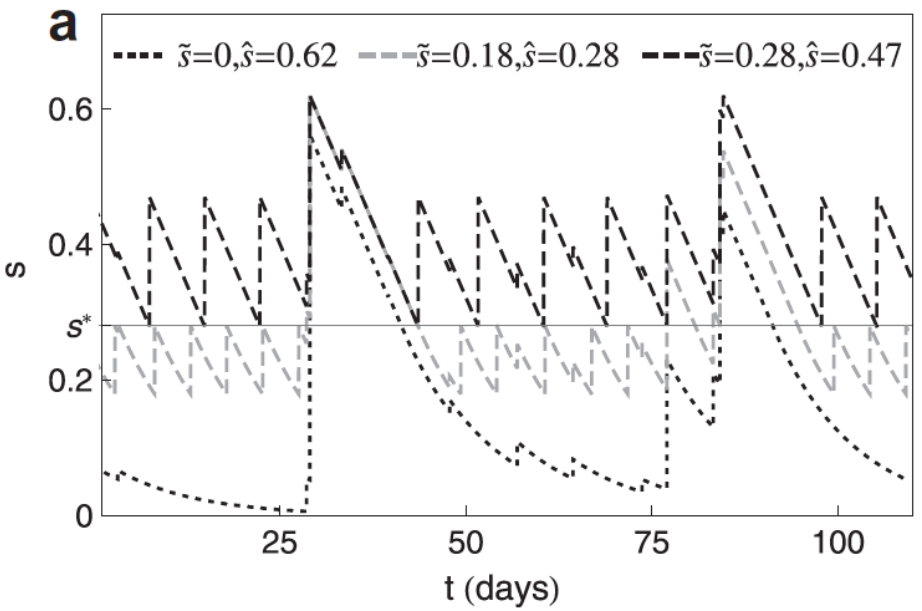


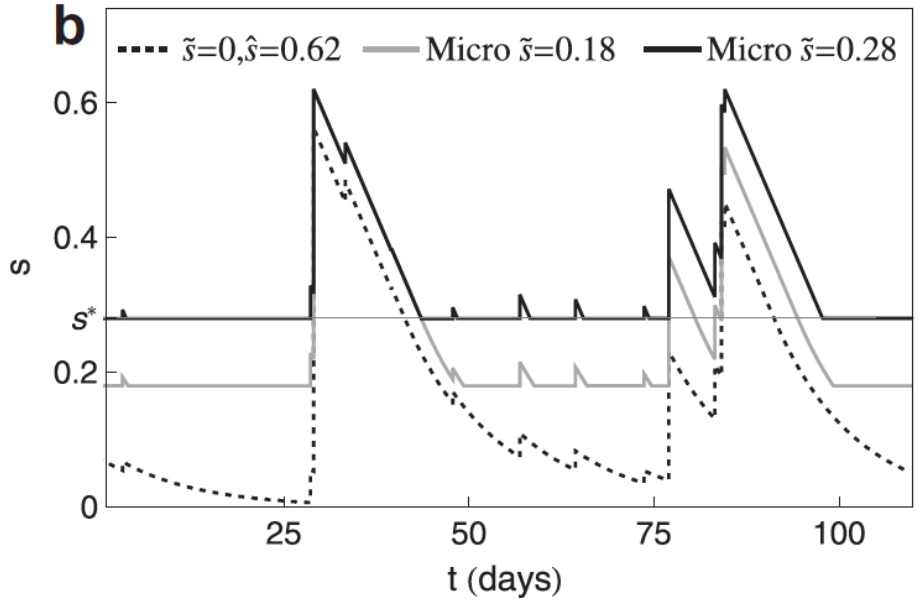
(a) Average soil moisture and (b) long-term soil water balance for fixed total growing season rainfall depth (R_{tot} = 400 mm) and variable l and a, for rain-fed agriculture (short-dashed lines), microirrigation (solid lines), and traditional irrigation (long-dashed lines). In Figure 2a the dash-dotted line represents s*. In Figure 2b, irrigation volumes, V, are compared to deep percolation and runoff losses, LQ (short-dashed line refer to LQ for rain-fed agri- culture). The components of the water balance are expressed as volumes per unit area, i.e., depths. The growing season duration, T_{seas}, is assumed to be 180 days; all the other para-meters are as in Figure 1.

Comparison between irrigation methods

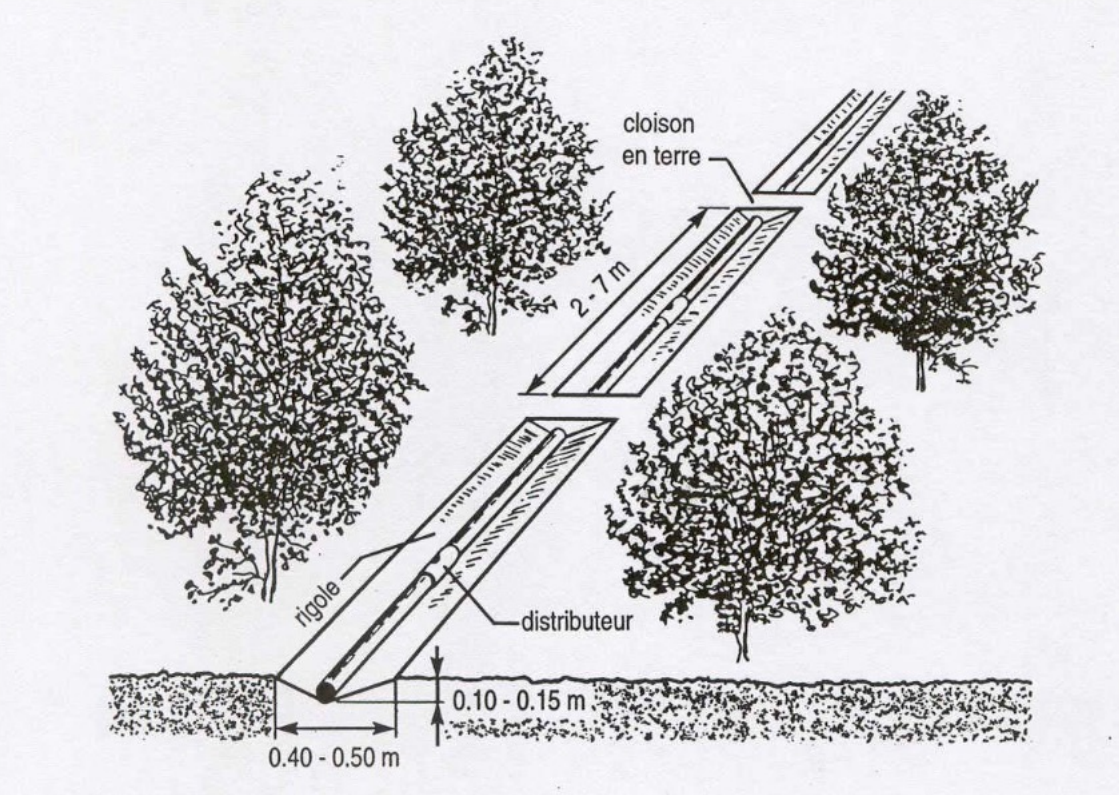
After Vico and Porporato, Advances in Water Resources, 2011





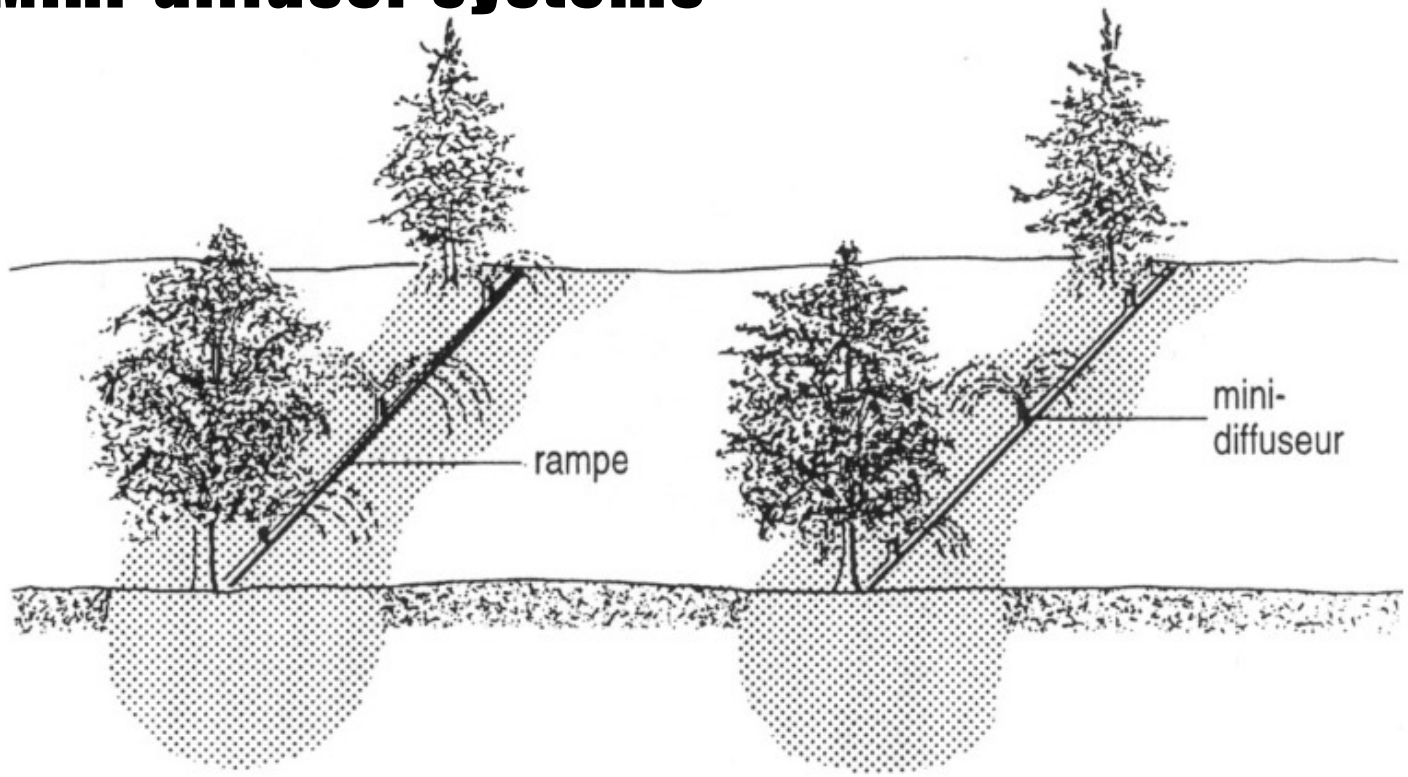


Line system (Bas-Rhône)

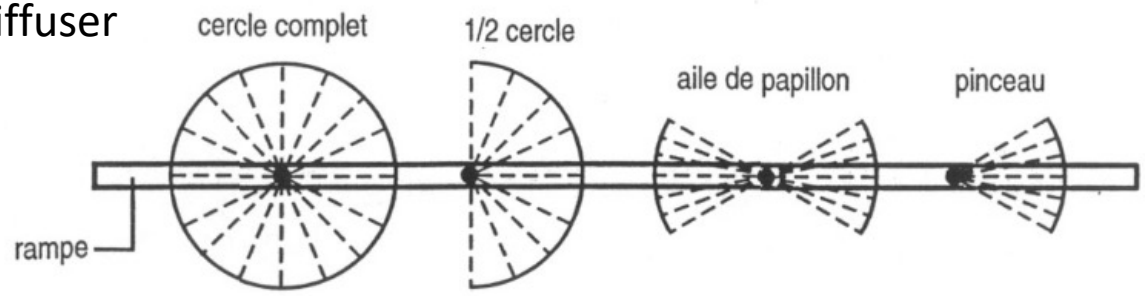


Water distribution is done by means of calibrated nozzles of variable diameter (1.2 – 2.1 mm), deployed as derivation of a PE ramp (dimater 25 mm ca.) layed down within shallow furrows parallel to the tree line

Mini-diffuser systems



Shape of the irrigated surfaces depending on the type of mini-diffuser

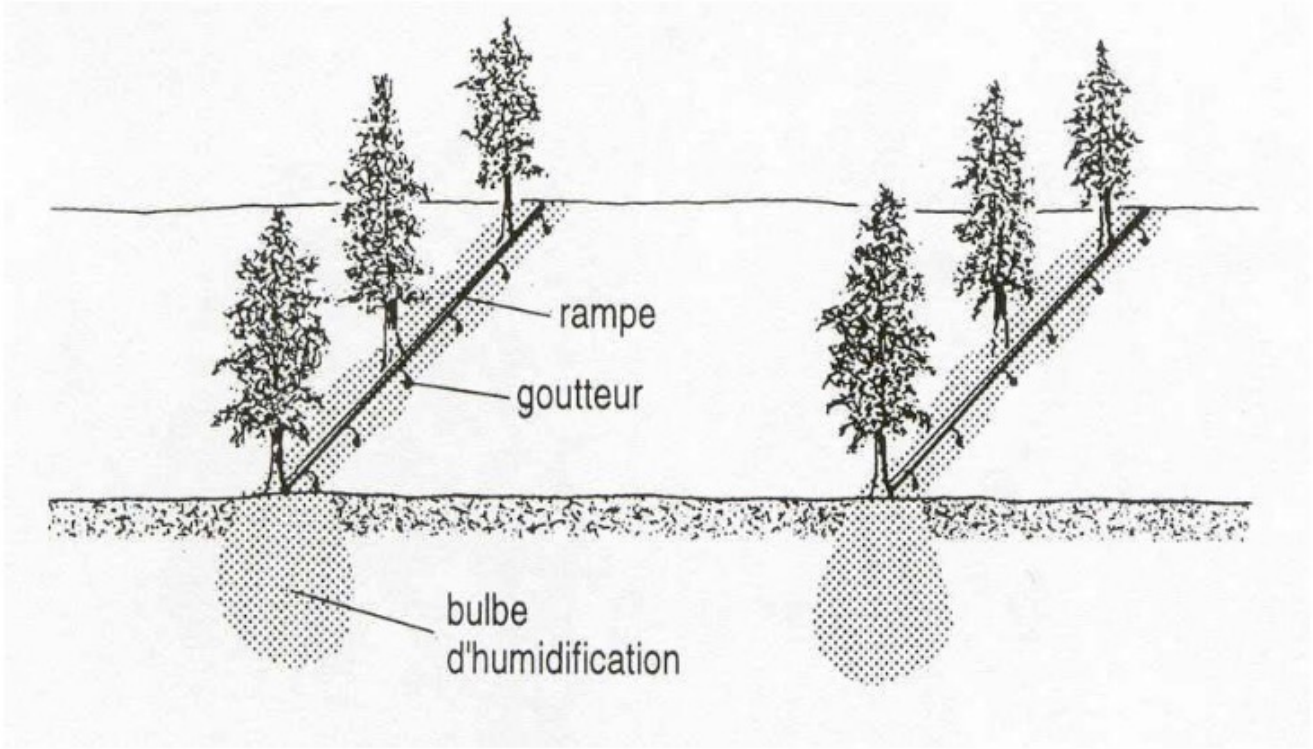


Done by means of small static sprinklers whose continous jet only covers the surface occupied by the crops.

<u>Mini-diffuser</u>
Operating pressure: 1 – 2 bars
Flowrate: 20 – 60 l/h (occasionally 120 l/h and up to 6 bars for self regulating devices)

<u>Distributing ramp</u>
- Buried or above the soil (diffuser elevated 50 cm above soil)
- Suspended (diffuser attached directly to the ramp)

Dripping system (goute à goute)

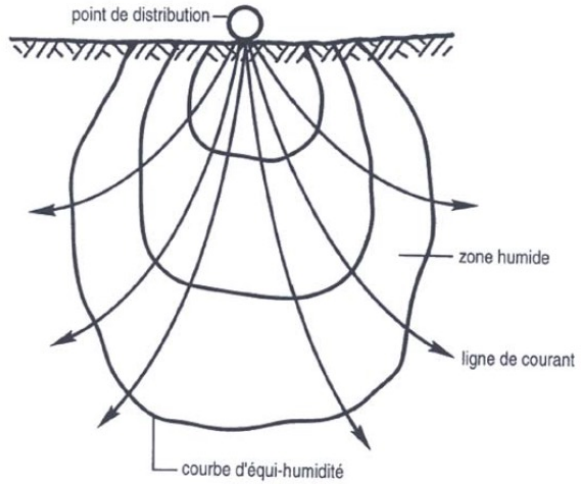


Water is deliverd by drippers, which function at low pressure (<1 bar) and punctually deliver a flowrate of max 10 l/h

This system is the most used worldwide and so we shall concentrate on this one.

Principal factors governing micro-irrigation

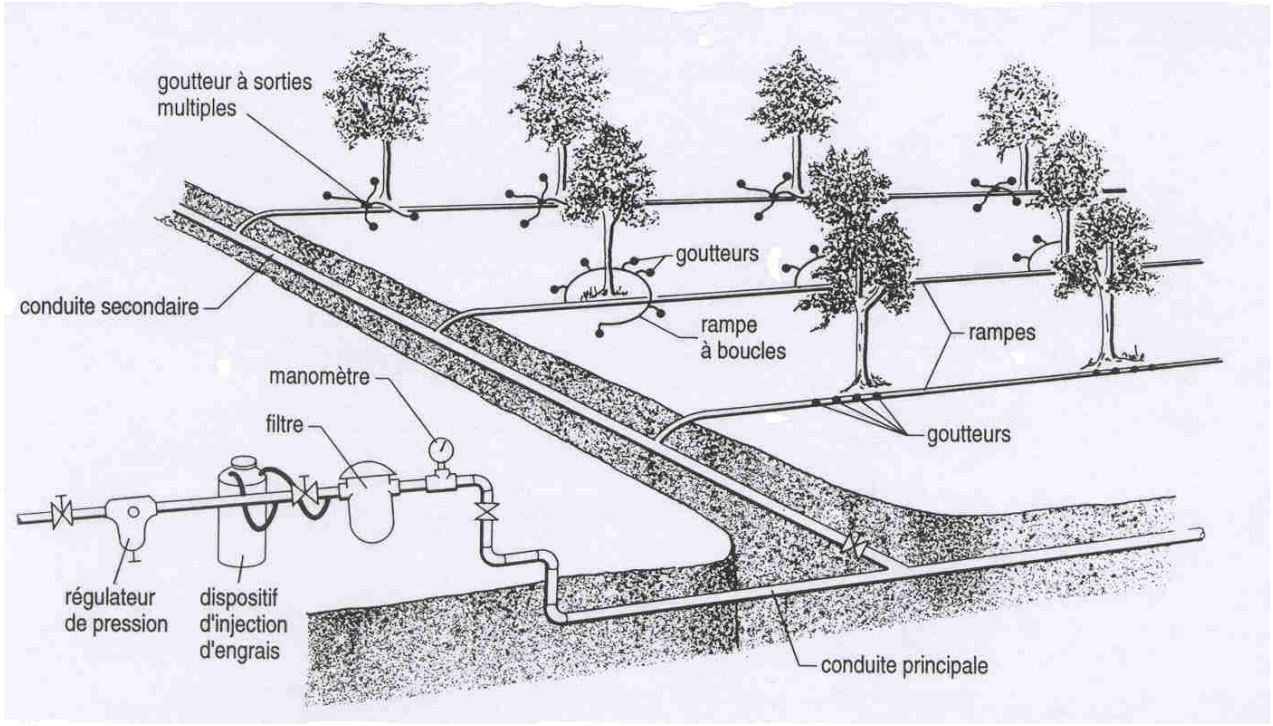
- soil characteristics → bulb shape and dripper density
- water quality → risk of clogging and soil salinisation
- topography → uniformity of distribution
- type of crops



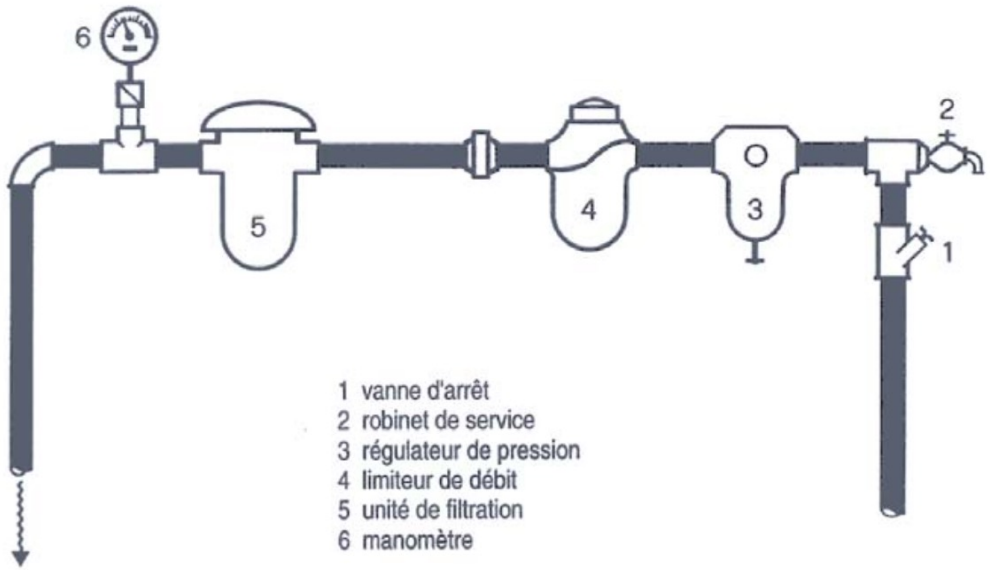
General deployment

- water point (pressure line from surface or GW sources)
- head installation (to control, regulate, filter,integrate, etc.)
- network of main pipes (generally buried, in PVC or PE)
- network of secondary pipes (manifolds) (buried or above ground, PVC or PE)
- ramps supplying the distributors (generally in flexible PE, diameter: 10 - 30 mm)

  - laid on the ground
  - laid above ground

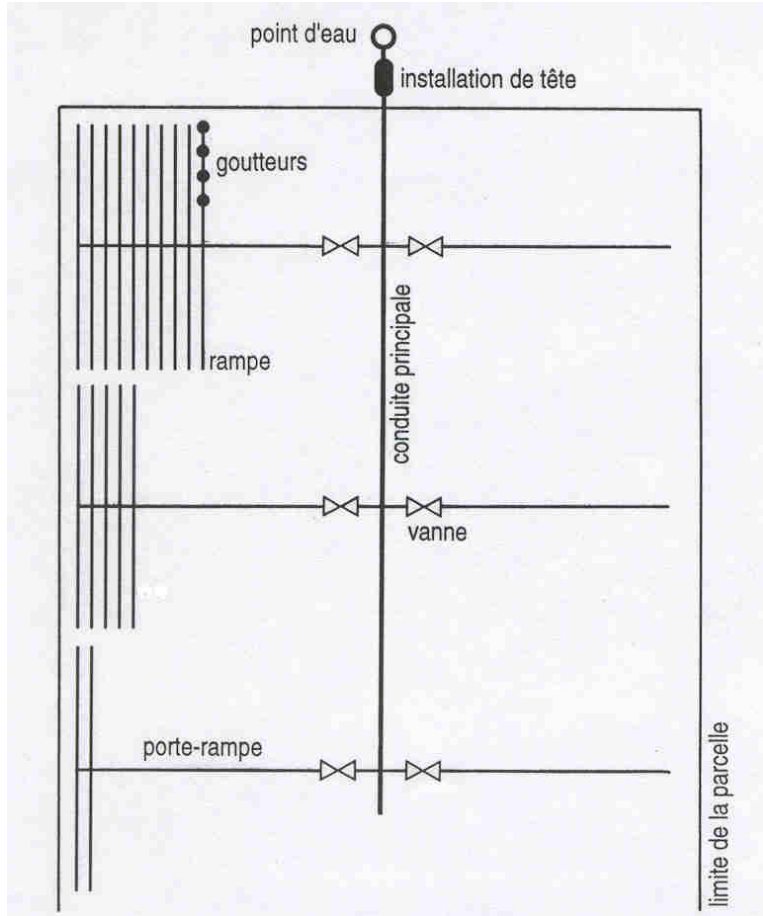


Head installation example

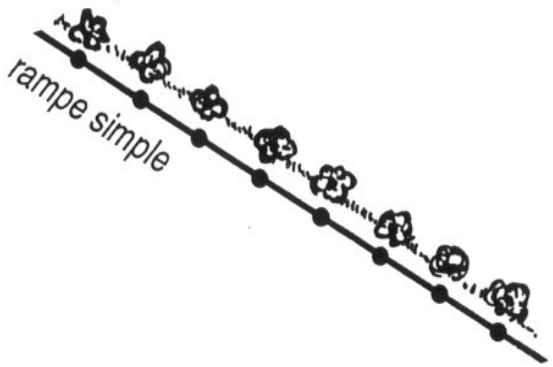


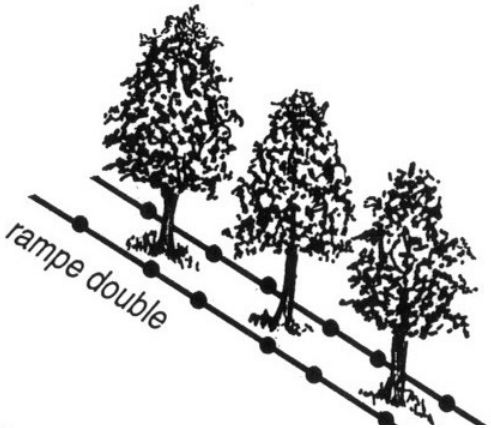
General scheme

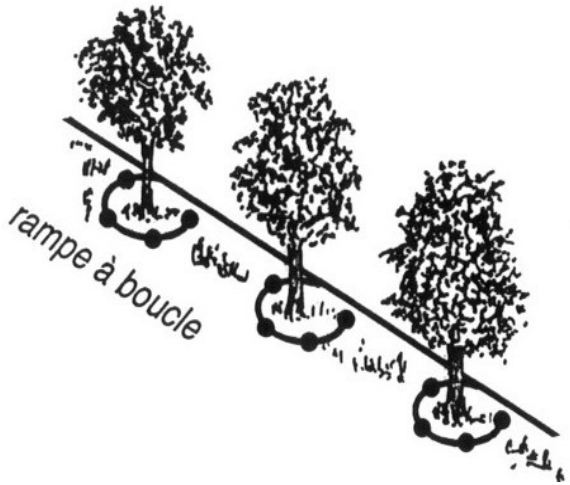
- Generally fixed networks
- Easy to automate



Ramps deployment



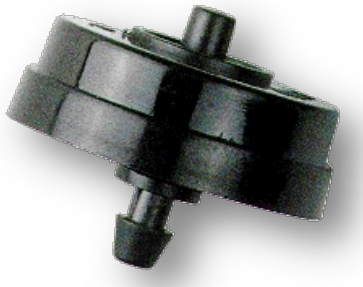




Classification of the drippers

- Ramp mounting method
- Number of outlets
- Pressure dissipation mode

Dripper in derivation



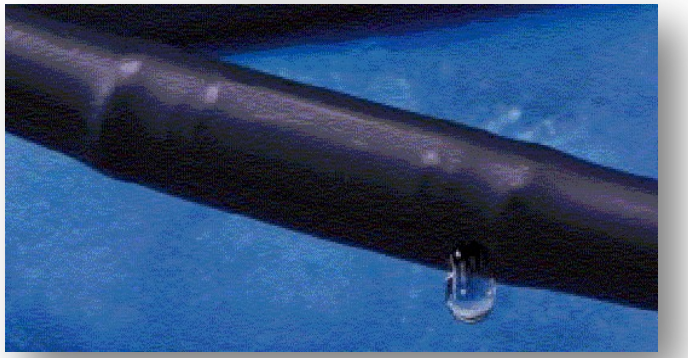
Grooved end

Online dripper

Grooved end

Inserted into the pipe, after cutting, by means of 2 fluted end pieces

Integrated dripper



Inserted into the pipe as it is extruded; the pipe is not severed

Drippers choice

- type of crops
- soil type
- topography
- water quality
- financial resources, etc.

Desired characteristics

- Low, regular flow rate (qq litres per hour)
- Low sensitivity to pressure variations
- Orifices of appropriate diameter d:

  $d < 0.5$ mm → high susceptibility

  $0.5 < d < 1.0$ mm → medium susceptibility

  $d > 1.0$ mm → low susceptibility

- Cheap solution*

→ **Choice = compromise between technical and economic requirements**

* Drippers may represent 25 to 60% of the cost of the network

Special parts

Raccord

T

Vanne

Coude

Collier de prise

Réduction

Bouchon

fin de ligne

Hydraulic functioning of drippers

$$q = b H^{\beta}$$

b: dripper constant

β : flow characteristic

Values of β :

- laminar flow (capillaries, porous pipes)

$$\beta \cong 1$$

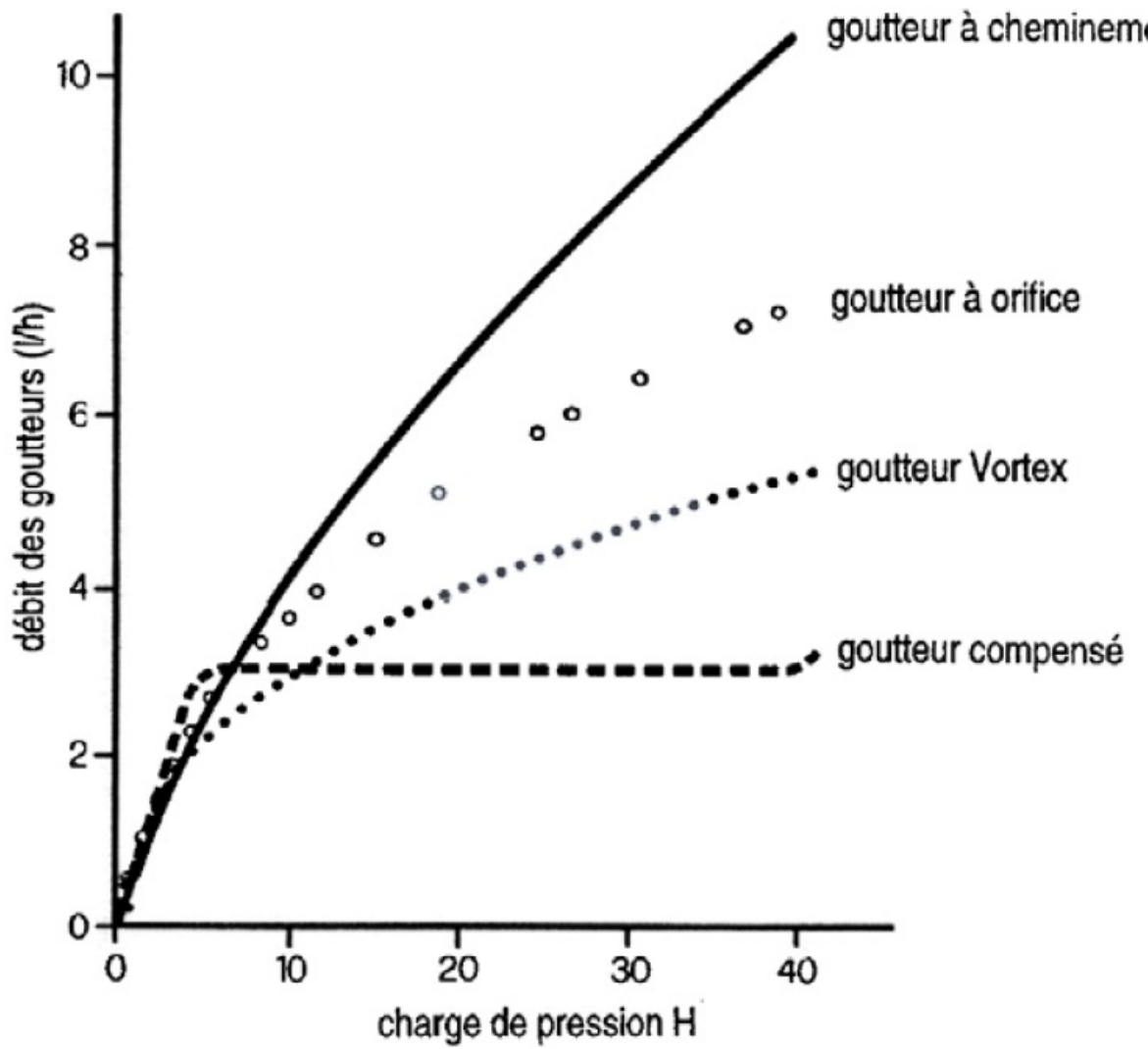
- partially turbulent regime

drippers with path $0.5 < \beta < 0.8$

- turbulent regime

  - *orifice drippers* $\beta \cong 0.5$
  - *vortex drippers* $\beta \cong 0.4$
  - *compensated drippers* $0 < \beta < 0.25$

$$q = b\,H^{\beta}$$


goutteur à cheminement
goutteur à orifice
goutteur Vortex
goutteur compensé
débit des gouteurs (l/h)
charge de pression H
0
2
4
6
8
10
0
10
20
30
40