Irrigation and Drainage Engineering

(Soil Water Regime Management)

(ENV-549, A.Y. 2024-25)

4ETCS, Master option

Lecture 8-1. Micro-irrigation: Deployment of drippers, risks and fertigation

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Platform of Hydraulic Constructions

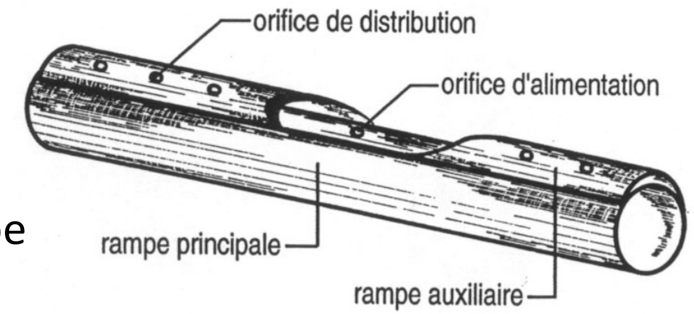
Drippers classification

This is done depending on how pressure is dissipated

a) Perforations made directly on the ramp = perforated sheaths :

- Single wall
- Double wall (Bi - Wall)

Bi-Wall pipe



This system is particularly suitable for cultures planted in lanes (CM)

b) Long-circuit drippers :

- Capillary tube drippers
- Helical circuit drippers
- Turbulence effect drippers

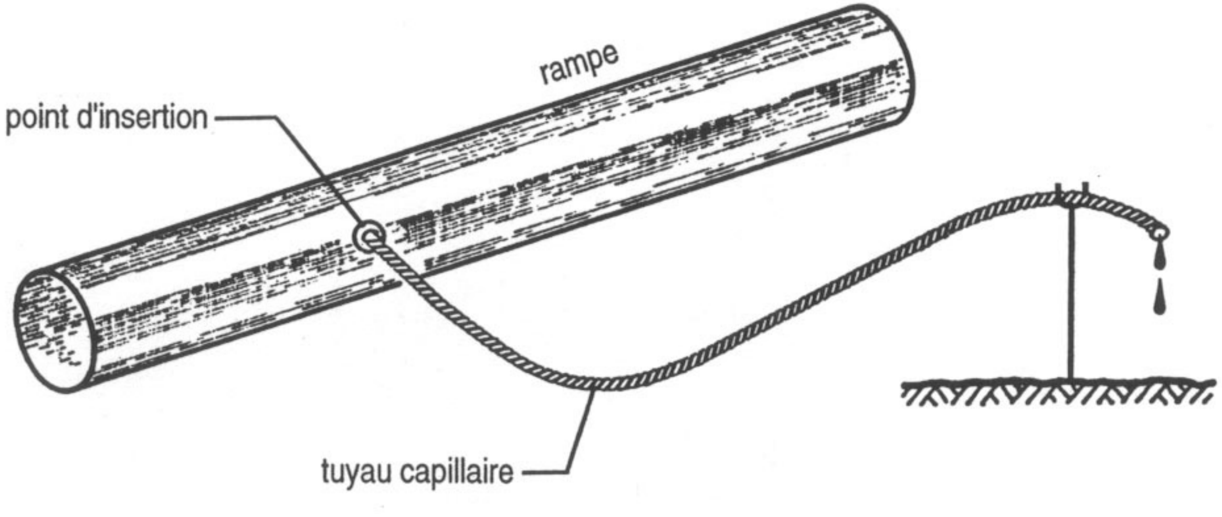
c) Short circuit drippers :

- **Orifice drippers**
- **Vortex drippers**

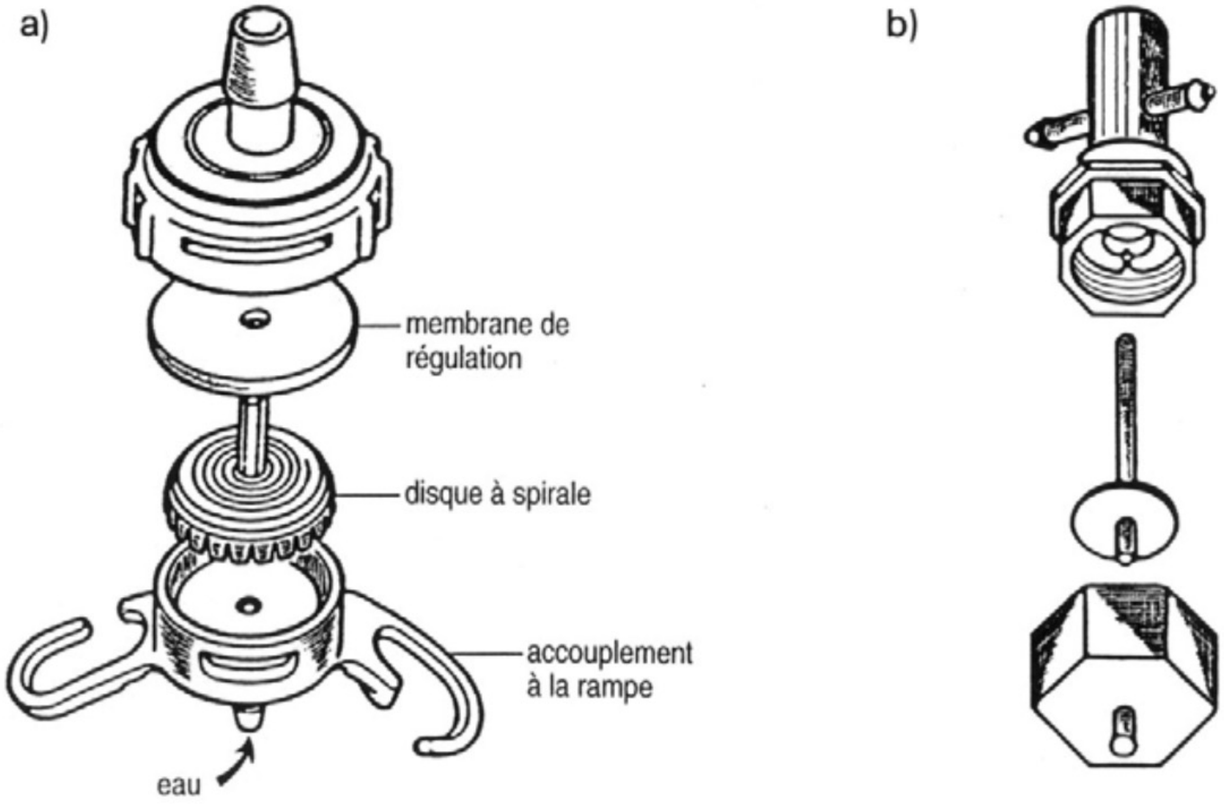
d) Pressure-compensated drippers

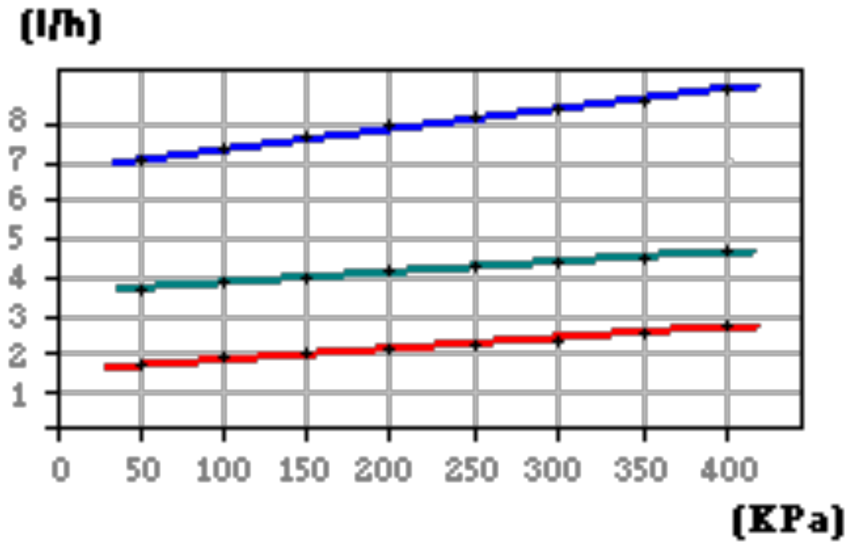
} Fruit growing, viticulture, etc.

Capillary tube drippers

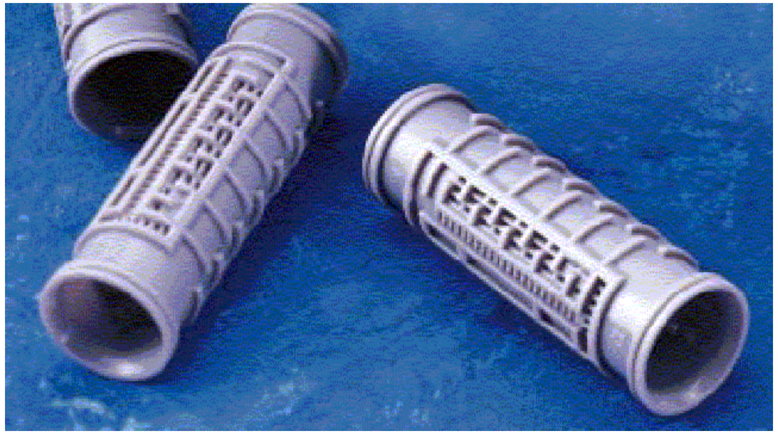


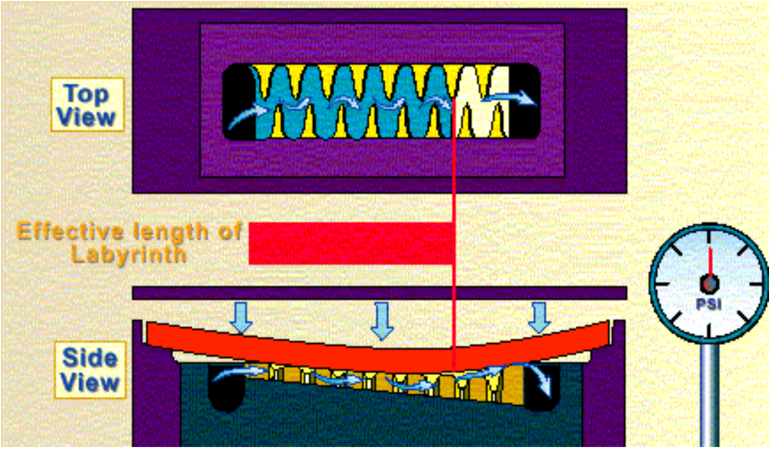
Pressure-compensated drippers (on-line)

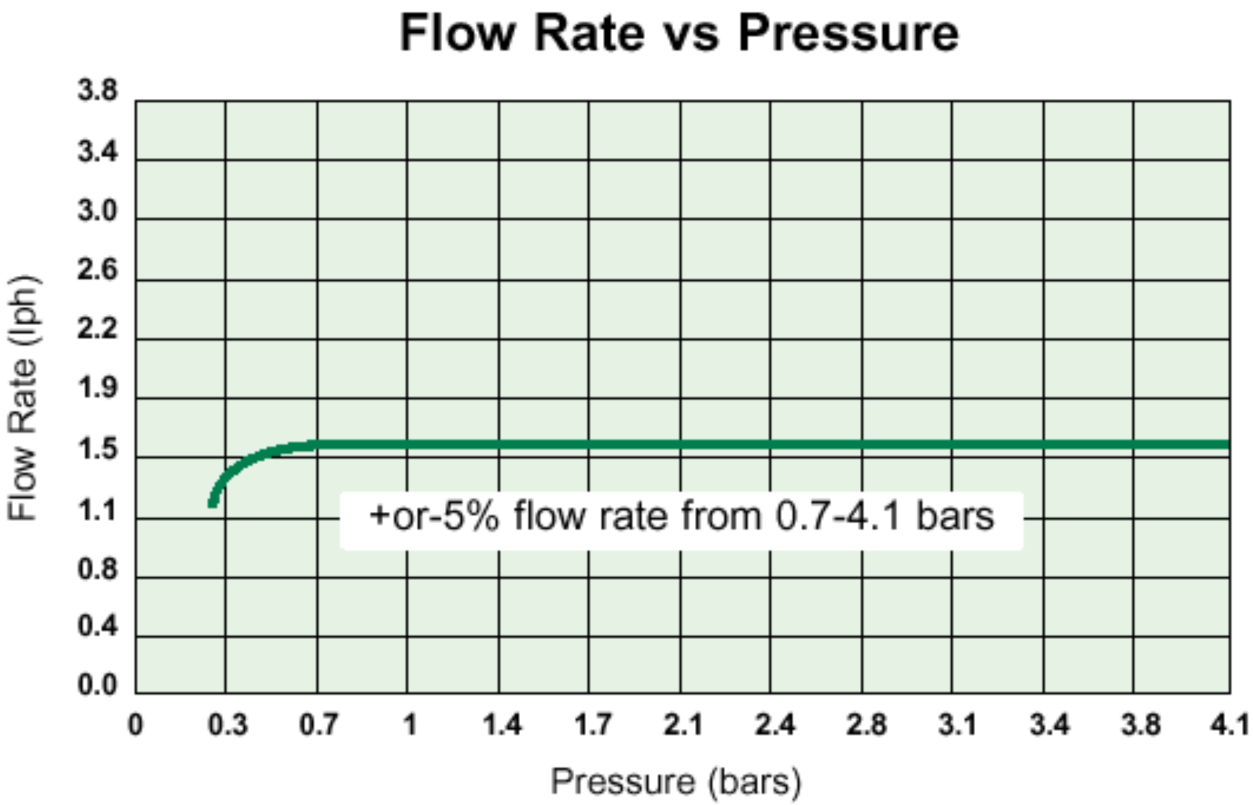




Pressure-compensated drippers (in-line)



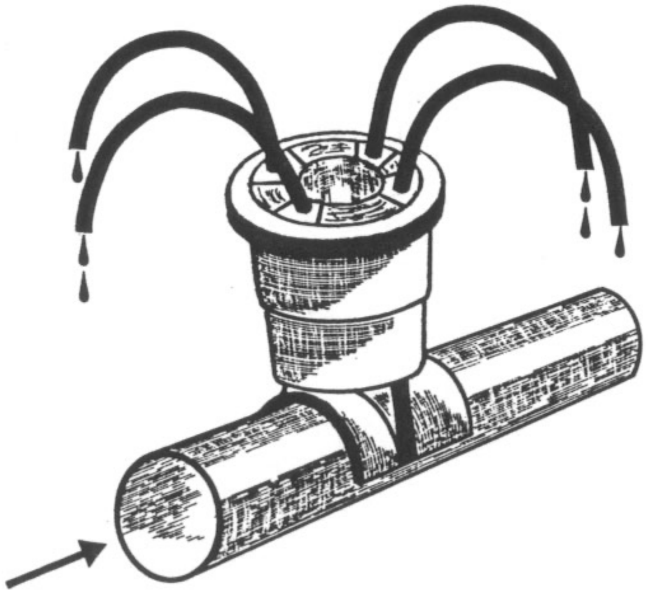




Variants

Single-drip version

Multi-drip version



Mounting the drippers

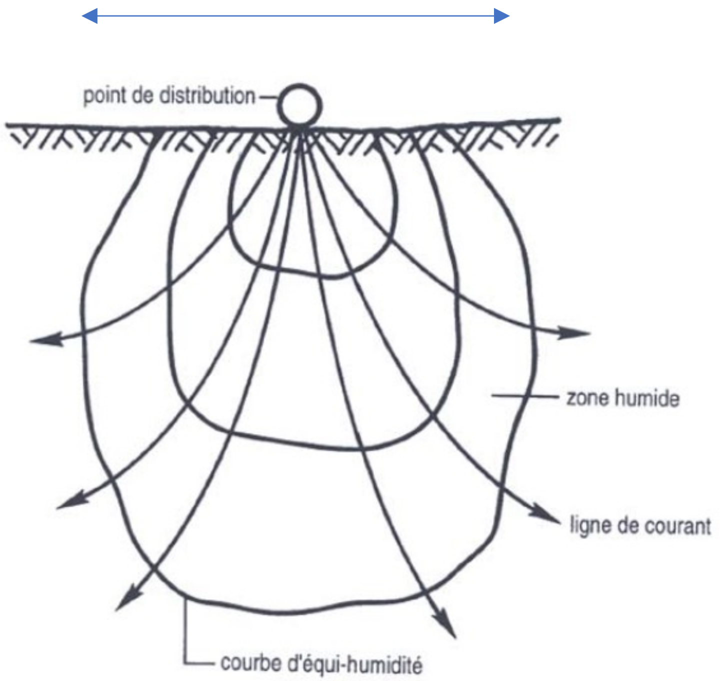
Dripper spacing and ramp spacing depend on :

- the type of crop
- characteristics of the humidification bulb

Size, shape and moisture content of the bulb :

- ✓ hydraulic properties of the soil
- ✓ dripper flow
- ✓ frequency and duration of irrigation
- ✓ climatic conditions
- ✓ type of crop

The lateral extension of the bulb is generally between 0.5 and 2.0 m.



→ Usual dripper spacing: 0.5 to 2 m.

$$K(h) = K_s \, e^{\alpha h} \qquad (1)$$

α est une constante caractéristique du sol, plus élevée dans les sols grossiers que dans les sols fins.

$$q = \frac{\pi \rho^2 i}{1000} \quad \text{soit,} \quad \rho = \sqrt{1000 \frac{q}{\pi i}}$$

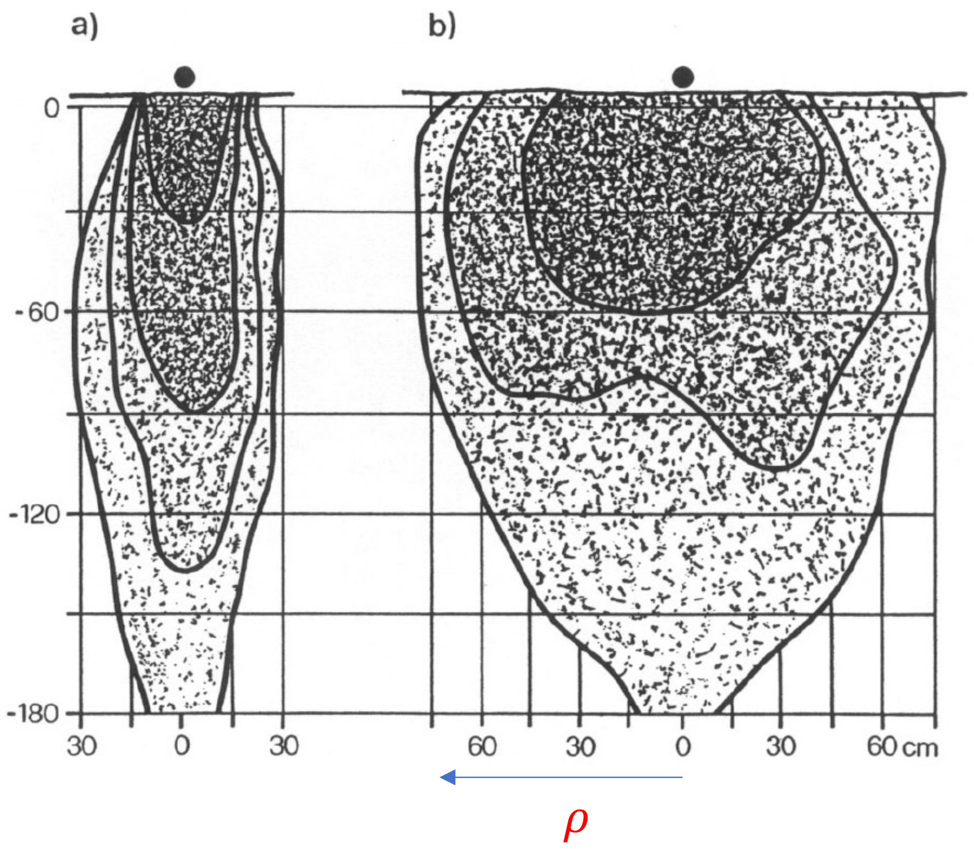
q : débit du goutteur, en $l \cdot h^{-1}$

i : capacité d'infiltration, en $cm \cdot h^{-1}$

Steady state i → K_s → $\rho = \sqrt{1000 \frac{q}{\pi K_s}}$

If suction is important, then (Wooding 1968)

$$\rho = -\frac{2}{\alpha \pi} + \sqrt{\frac{4}{\alpha^2 \pi^2} + 1000 \frac{q}{\pi K_s}}$$



$$\frac{\delta\theta}{\delta t} = \frac{\delta}{\delta r}\left(K(\theta)\frac{\delta h}{\delta r}\right) + \frac{K(\theta)}{r}\frac{\delta h}{\delta r} + \frac{\delta}{\delta z}\left(K(\theta)\frac{\delta H}{\delta z}\right)$$

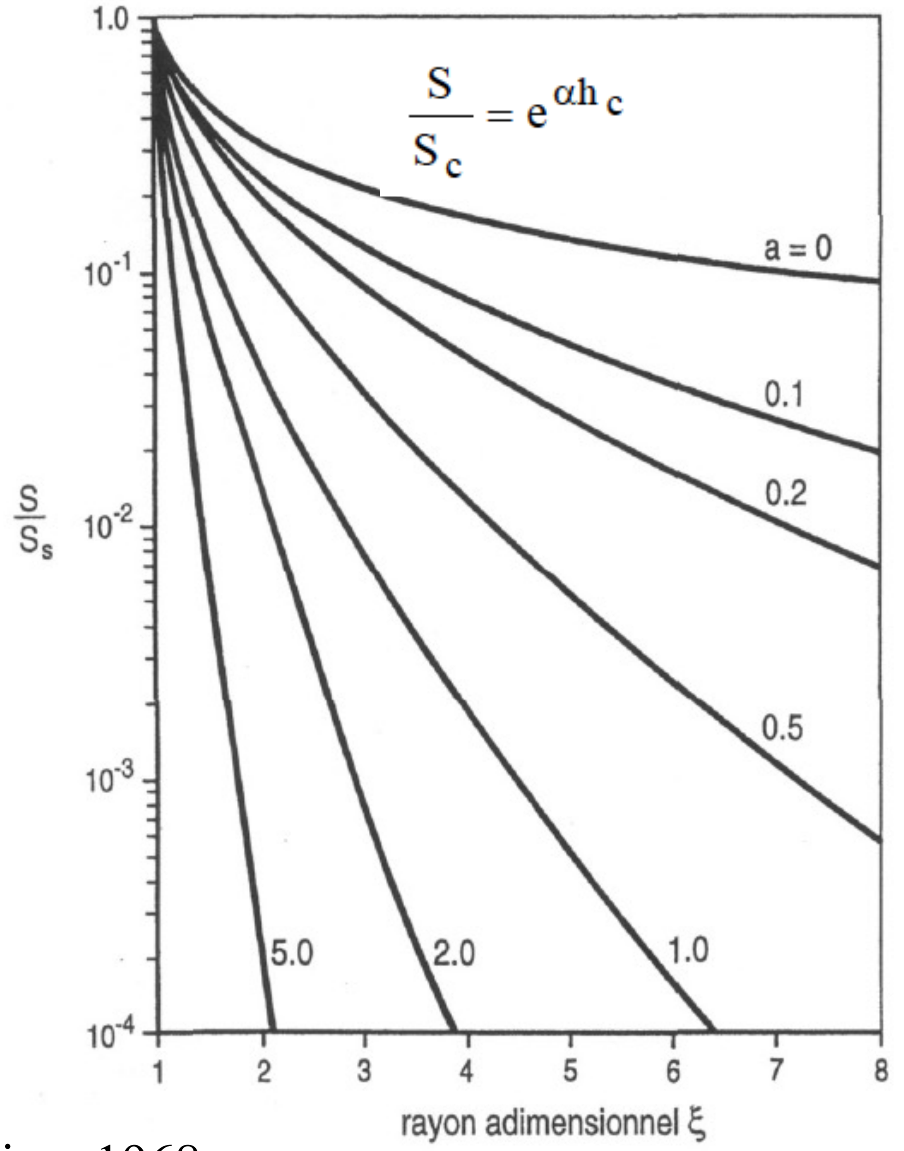
Richards equation (unsaturated soil)

$$\xi = r / \rho$$

et: $a = \alpha\rho / 2$

- r : distance radiale entre le goutteur et la zone où h = h_c
- ρ : rayon de la tache saturée de surface (éq. 19)
- α : paramètre de la relation K(h)

1.- déterminer les paramètres α et K_s du sol et se fixer une valeur de la charge de pression critique h_c
2.- calculer le rayon ρ de la tache saturée de surface, à partir de l'équation
3.- déterminer la valeur du rapport S / S_s
4.- calculer la valeur de a
5.- rechercher la valeur du rayon adimensionnel ξ au moyen de la figure 23
6.- en déduire la valeur de r (éq. 24) et celle de l'espacement s = 2r entre les goutteurs.



After Wooding, 1968

Obstruction risk

PLATEFORME DE CONSTRUCTIONS HYDRAULIQUES

- PHYSICAL (mineral or organic particles)
- CHEMICAL (carbonates, oxides, sulphides, etc.)
- BIOLOGICAL (algae, bacteria, spores, etc.)

→ *Filter unit essential*

Depending on the case, all or some of the following devices:

- Pre-filtration device
- Sand filter
- Strainer

Sizing main pipes and trapeze holders

Formule de Hazen-Williams

$$j = 2.78 \cdot 10^{-6} \left(\frac{Q}{C}\right)^{1.852} D^{-4.87}$$

j : linear head loss
Q : pipe flow rate (m^3/h)
D : pipe diameter (m)
C : head loss coefficient

Plastic pipes:	120 < C < 150
Cast iron pipes:	100 < C < 130
Steel pipes:	100 < C < 110

Formule de Darcy-Weisbach

$$j = \frac{\lambda}{D}\frac{v^2}{2g} = \frac{\lambda}{D}\frac{Q^2}{2gS^2}$$

j : linear pressure drop
D : pipe diameter
v : average water velocity
Q : pipe flow rate
S : pipe cross-section
λ : head loss coefficient

Ramps design

The ramp is the conduit that feed the drippers, i.e. to which the drippers are either on-line or in-line connected.

Q= N q	flowrate entering the ramp
N= L/s	N, number of drippers; L= ramp length s, interspace between drippers

Qualités exigées:

- ✓ *flexible*
- ✓ *non-corrosive*
- ✓ *resistant to radiation*
- ✓ *easy to handle*
- ✓ *opaque*

Formule de Hazen-Williams

$$\Delta H = 2.78 \cdot 10^{-6} \, F \, L \, D^{-4.87} \left(\frac{N q}{C_g} \right)^{1.852}$$

ΔH: pressure drop in the ramp (m)*

L : length of ramp (m)

D : boom/ramp diameter (m)

N : number of drippers on the boom

q : average dripper flow rate (m3/h)

F : flow reduction coefficient (N > 20, F = 0.36)

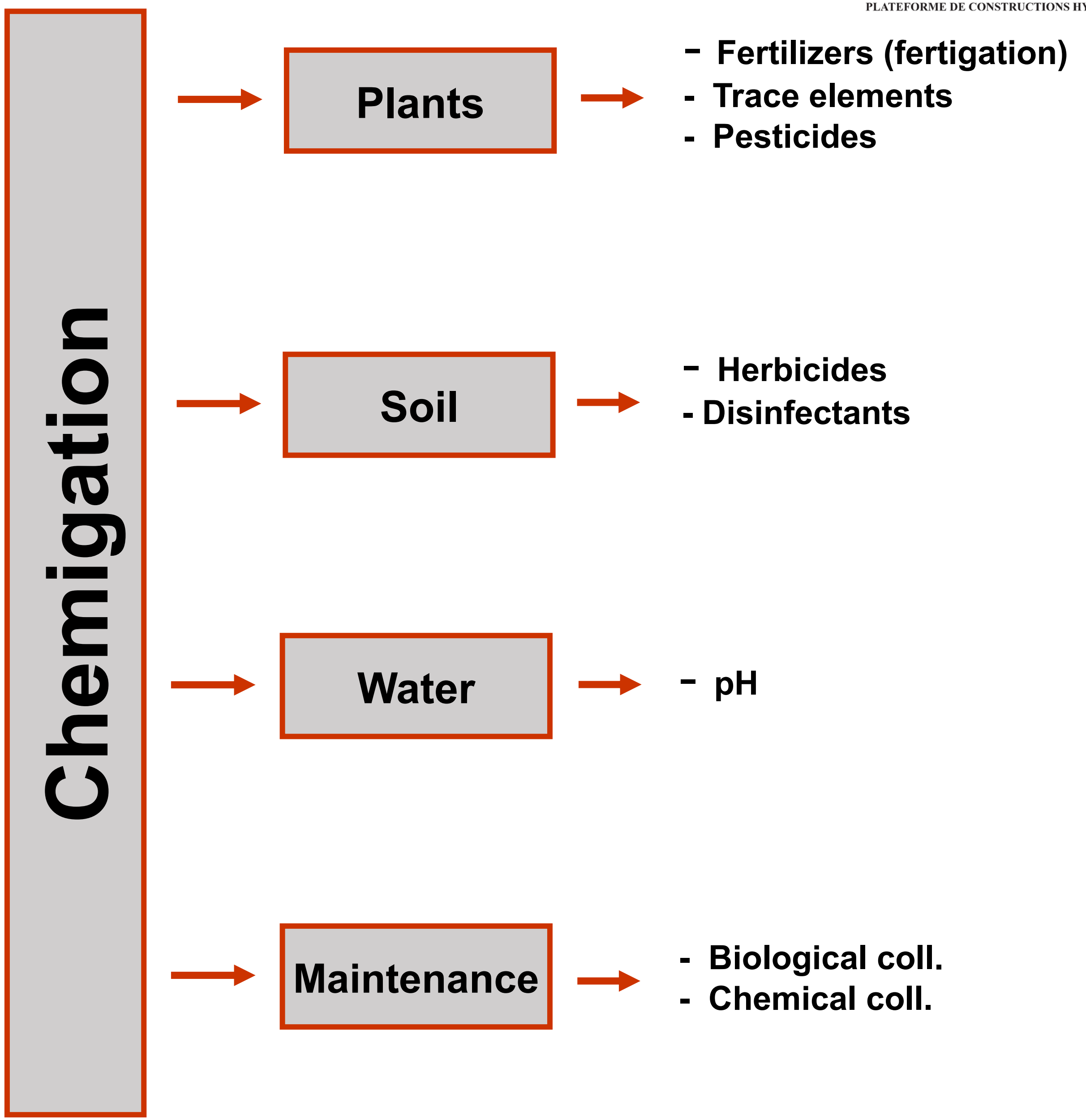
Cg: head loss coefficient (80 < Cg < 140)

* $\Delta H = \Delta H_f/3$, estimate from the total loss as the ramp would deliver the whole flow

Chemigation and fertigation

Chemigation is a general term associated to the artificial apportion of chemical either organic or inorganic compounds, whose function is thestatus preservation or improvement of plant, water, soil and maintenance.

Fertigation is the generically referred to chemical provided to plant crops



Fertigation

Fertigation success factors

a) Installation design

- ✓ non-return valve
- ✓ sieve filter after injection system
- ✓ even water distribution

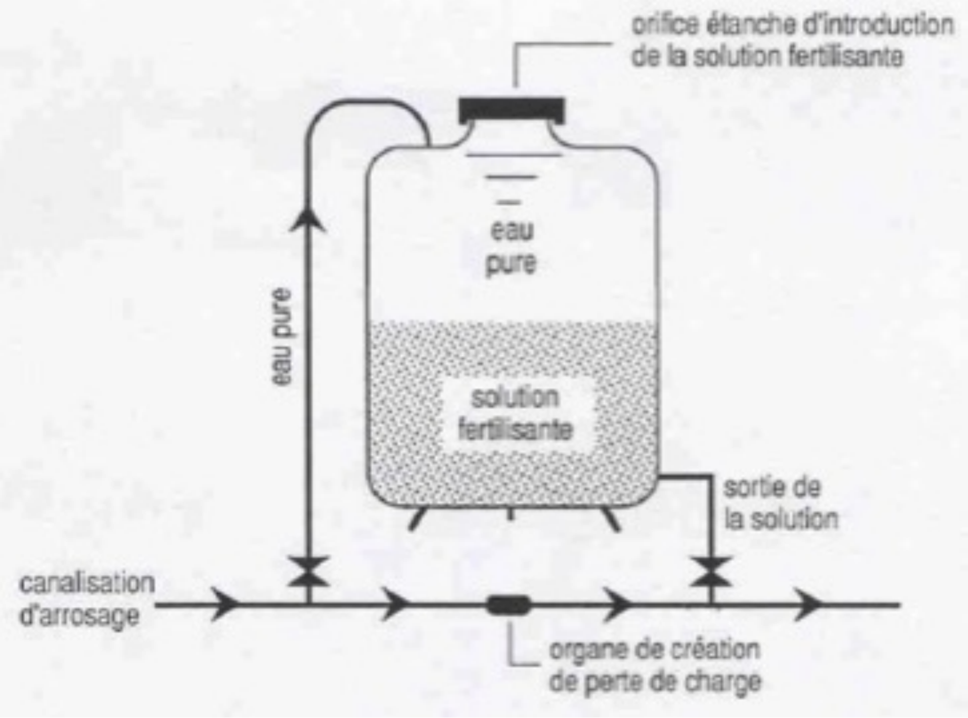
b) Wise choice of fertilisers

(especially phosphate fertilisers)

- ✓ use acidifying phosphate fertilisers
- ✓ if necessary, lower the pH → 7

c) Adequacy of supply/needs

d) Rinsing after injection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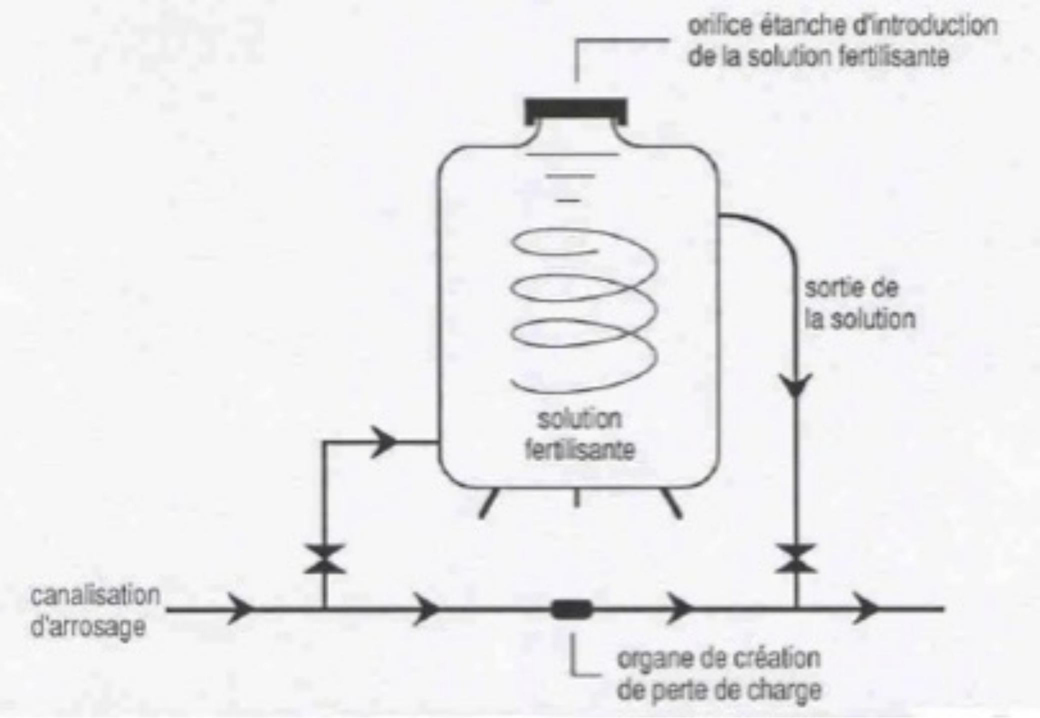
de perte de charge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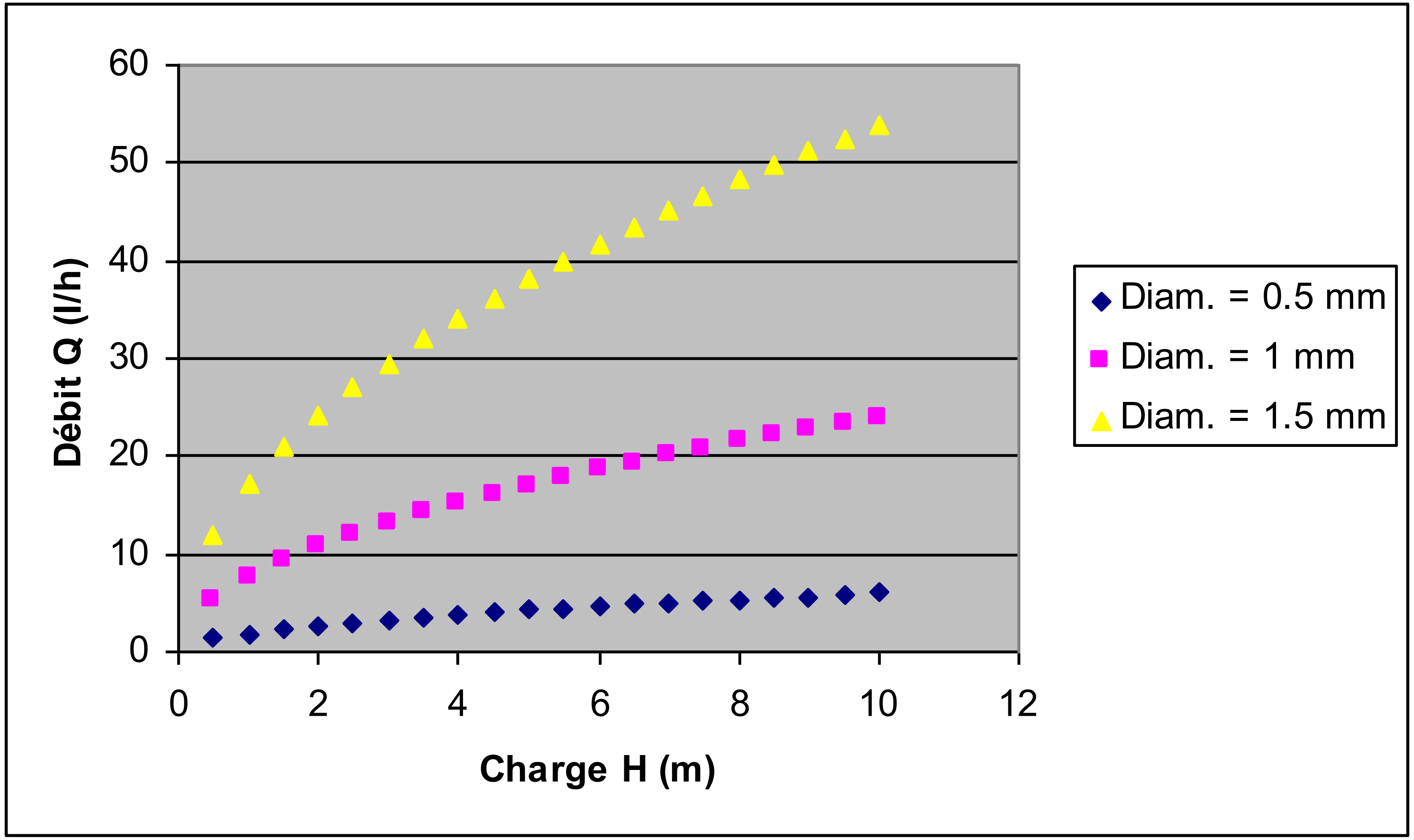
Influence of orifice diameter on flow variations



β= 0.5

C = 0.6

Saturated surface stains under drippers

Drip irrigation examples