

# Irrigation and Drainage Engineering

(Soil Water Regime Management)

(ENV-549)

4ETCS, Master option

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Platform of Hydraulic Constructions



Project: flooding in  
Nouakchott (Mauritania) –  
Water demand

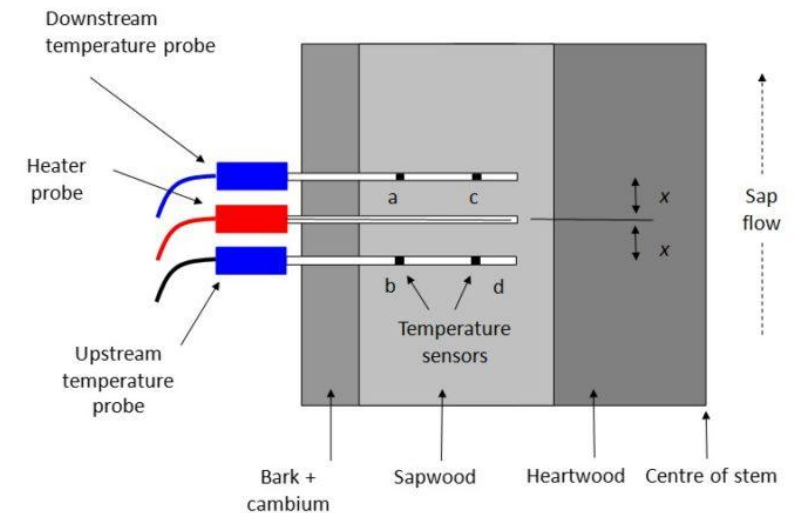
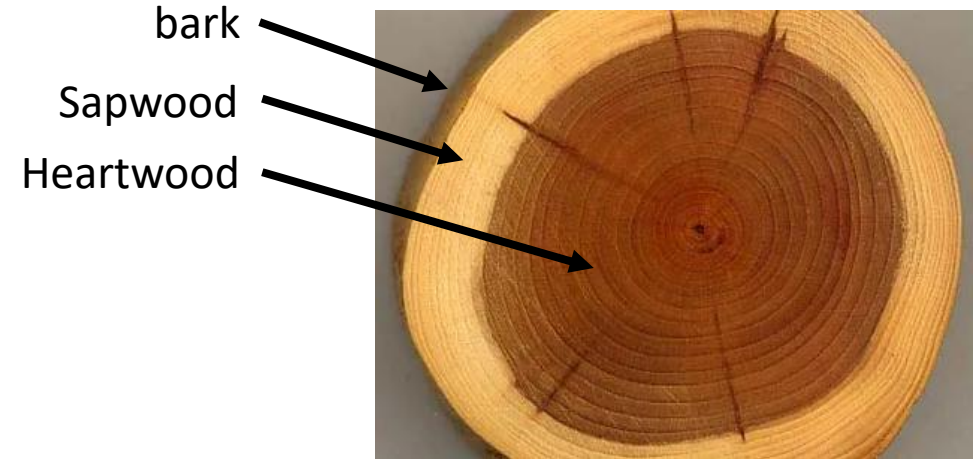
# In-situ transpiration measurement

- In **dicot trees** = sap mainly flows in the sapwood
  - ➔ Sap flow meters directly set on the trunk
  - ➔ Tree transpiration = sap velocity x sapwood area

➔ Allometric function to estimate sapwood area as a function of the trunk diameter at breast height (DBH)

$$S_A = 0.728 \times DBH^{1.998}$$

With  
 $A_s$  the sapwood area



# Irrigation practice

$$B_n = ETM - P_e - R = K_c ET_o - \alpha P - R$$

$B_n$ : net irrigation water requirements

ETM: maximum evapotranspiration

$P_e$ : effective precipitation

R: reserve available at the start of the calculation period

$K_c$ : crop coefficient

$ET_o$ : reference evapotranspiration

$\alpha$ : rainfall reduction coefficient

P: total rainfall

- *Irrigation not continuous, but intermittent*
- *Root zone = reservoir characterised by critical thresholds:  $q_{cr}$  and  $q_{ft}$*

→ ***need to define some irrigation parameters***

- flow rate to be supplied to the operator
- dose to be applied
- frequency of watering
- duration of watering, etc.



# Effective water need

$$B = \frac{B_n}{E}$$



B : actual irrigation water need over the considered period (1 month, 1 decade, 1 day, etc.), in mm or m<sup>3</sup>/ha

B<sub>n</sub> : net water need, in mm ou m<sup>3</sup>/ha

E : global irrigation efficiency

# Irrigation dose

## Maximal irrigation Dose

$$D_n = (\theta_{cr} - \theta_{ft}) h$$

$D_n$  : maximal net dose, in mm

$\theta_{cr}$  : soil retention capacity (field capacity), in  $m^3/m^3$

$\theta_{ft}$  : point de flétrissement temporaire, en  $m^3/m^3$

$h$  (or  $z_r$ ) : root depth zone, in mm

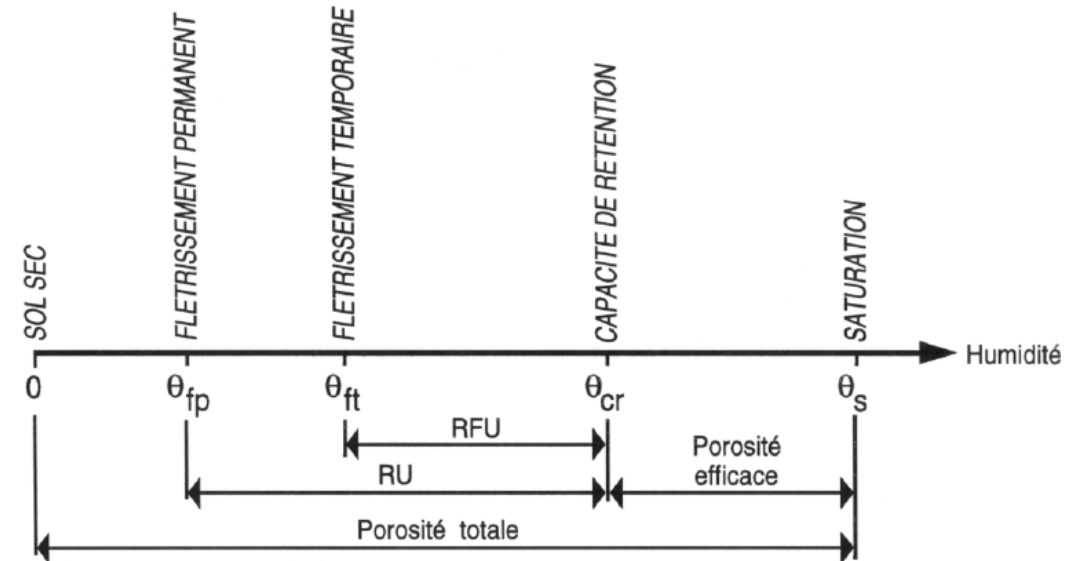
$$D_b = \frac{D_n}{e}$$

$D_b$  : Maximal actual (gross) irrigation dose, en mm

$e$  : plot delivery efficiency

KEY question: How much water (volume/area)?

Remember the scheme in Lecture 2-2



**Example:** Net requirements: 100 mm and net dose: 30 mm, i.e.:  $n = 3.33$   $n$  rounded to 4 or more and dose = 25 mm or less (e.g., 20 mm if  $n$  is 5)

# Irrigation frequency

$$n = \frac{B_n}{D_n}$$

KEY question: How often should we provide the irrigation dose?

$n$  : number of gross irrigation doses during the considered period\*

$B_n$  : net water needs during the considered period, in mm

$D_n$  : net irrigation dose, in mm

$$n = \frac{\text{Besoins bruts à la parcelle}}{\text{Dose brute}} = \frac{B_n / e}{D_n / e} \quad e : \text{efficience à la parcelle}$$

→ *n is rounded up to the nearest unit and the actual dose is reduced accordingly*



\* It is indifferent the use of the net or the actual dose, given that both the dose and the needs will be divided by the efficiency at the plot

### Furrow irrigation



Efficiency: 20 à 60%

### Sprinkler irrigation



Efficiency: 65 à 85%

### Micro-irrigation



Efficiency: 85 à 95%

### Indicative values of E :

- Gravity Irrigation :
  - Sandy soil    30 – 40    %
  - Silt soil       50 – 60    %
  - Clay Soil      60 – 65    %
- Sprinkler :                    65 < E < 85 %
- Micro-irrigation :            85 < E < 95 %

# 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

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

$\Delta H$ : pressure drop in the ramp (m)\*

L : length of ramp (m)

D : boom diameter (m)

N : number of drippers on the boom

q : average dripper flow rate (m<sup>3</sup>/h)

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

C<sub>g</sub>: head loss coefficient (80 < C<sub>g</sub> < 140)

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