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Advanced tools to predict water stress and its effect on yield
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# Irrigation scheduling: approaches and strategies

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# Presentation layout

1. **Introduction**
2. **Irrigation scheduling: approaches**
   - ✓ Measurement of plant water status
   - ✓ Measurement of soil water status
   - ✓ Calculation of crop-soil water balance

# (1) Introduction

- **Irrigation scheduling**

- At farm level, there is an effective request of **methods** to support 'real-time' **irrigation scheduling** ('when' to irrigate and 'how much' water to supply) with respect to
- the specific **crop response to stress** (and related water-yield relationship)
- to the need to **increase water productivity**
- to avoid **water losses** and **nutrient leaching** (environmental impact)
- to reduce **energy costs** (pressurized irrigation systems)

# (1) Introduction

- **Irrigation scheduling**
- Irrigation scheduling is **complex** because of the different combinations of crop types, soil characteristics, weather conditions and field management strategies. An **'ideal' irrigation scheduling method** should be:
- a) **sensitive** to small changes in the system (e.g. soil moisture content, evaporative demand, plant response);
- b) responding in **'real-time'** to changing conditions;
- c) readily **adaptable to different crops** or growth **stages**;
- d) **robust and reliable**;
- e) **user-friendly** (simple and practical);
- f) suitable for **computerized** and/or **automated** irrigation;
- g) **low cost**, both in terms of purchase or running costs.

- **Irrigation scheduling**

- Irrigation scheduling can be supported by several **technical and scientific approaches**, which can be broadly classified according to three main categories:
- 1) **crop-soil water balance calculations**;
- 2) **soil water measurements**;
- 3) **plant-based measurements**.
- For all of them, both **advantages** and **disadvantages** have been highlighted (Jones, 2004).
- Anyway, it could be expected that an appropriate design of an **'integrated' DSS**, based on different approaches and exploiting the potentialities offered **by new technologies**, can help to effectively overcome some of the limitations of each single method.

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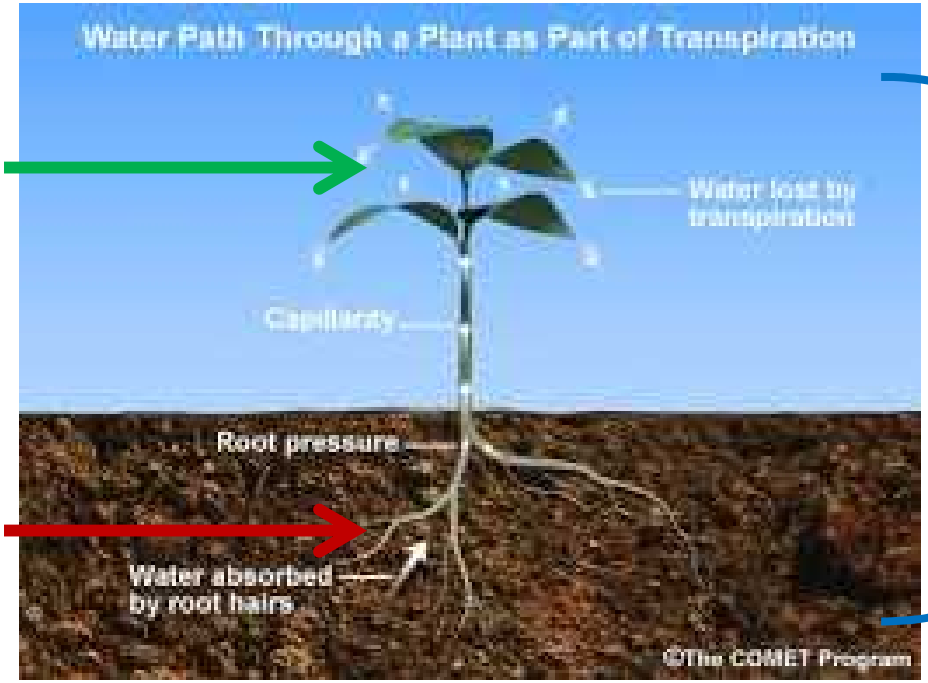
# (2) Irrigation scheduling: approaches

**Measurement of plant water status**

**Measurement of soil water status**

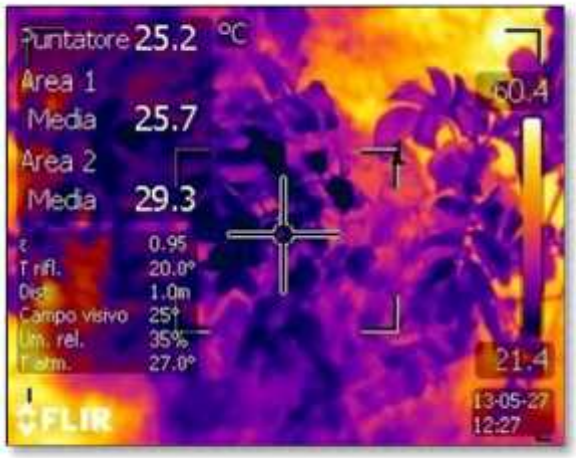



**Crop-soil water balance calculation**

# (1) Introduction

- **Measurement of plant water status**

| Methods | Advantages | Disadvantages |
|---|---|---|
| **Pressure chamber,** psycrometers, stem-trunk diameter, porometer, **thermal (IR)-camera, sap-flow, Zim probe** | **Direct measurement of plant water status/ response**; considering environmental effect; potentially high sensitivity | Don't quantify "how much" water to supply; **calibration is needed** to enstablish threshold values; in most cases the methods are still at the research stage |




# (1) Introduction

- **Measurement of plant water status**
- On the 'plant' side, innovative methods base t **m**
  **plant water relations** have been also propo tio
  (Jones, 2008).
- For example, the measurement of **leaf-stem** ial
  used to support deficit irrigation strategies ( 20
  required excessive manual operation;

- **p** explored as **'automatable'** alternatives,
  a ed irrigation control devices exploiting
  n **nk diameter**, **leaf/turgor** or **stem sap-**
  **fl**

- P t is **still in the research or development**
  s ommercial operations.
- T s **varies along the cropping cycle** which
  i blishing clear rules for their use in
  automated systems.

# (1) Introduction

- **Measurement of soil water status**

| Methods | Advantages | Disadvantages |
|---|---|---|
| **Tensiometers,** psycrometers, gravimetric method, **dielectric sensors/TDR,** neutron probe | Simply to apply; good precision; provide information on "how much" water to supply; availability of commercial soluntions; some sensors can be **integrated in automatic acquisition systems (data-loggers)** | Difficult to apply in heterogeneus soils; atmospheric evaporative demand is not considered, **the level of plant stress is not considered/measured** |

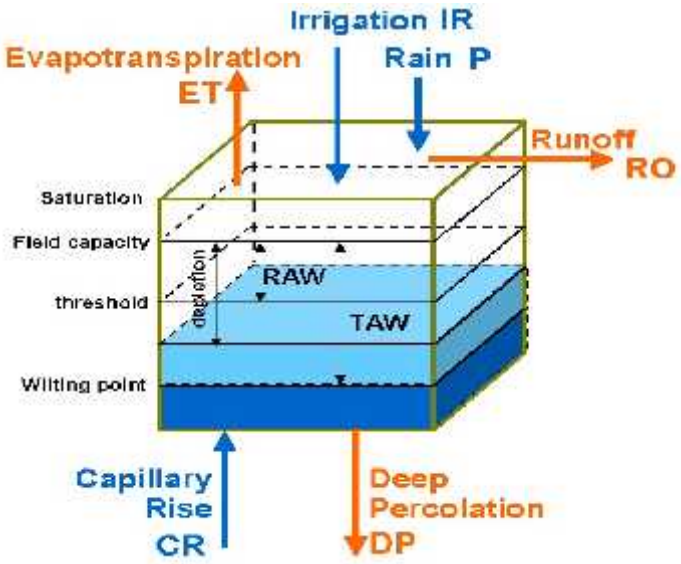
- **Measurement of soil water status**

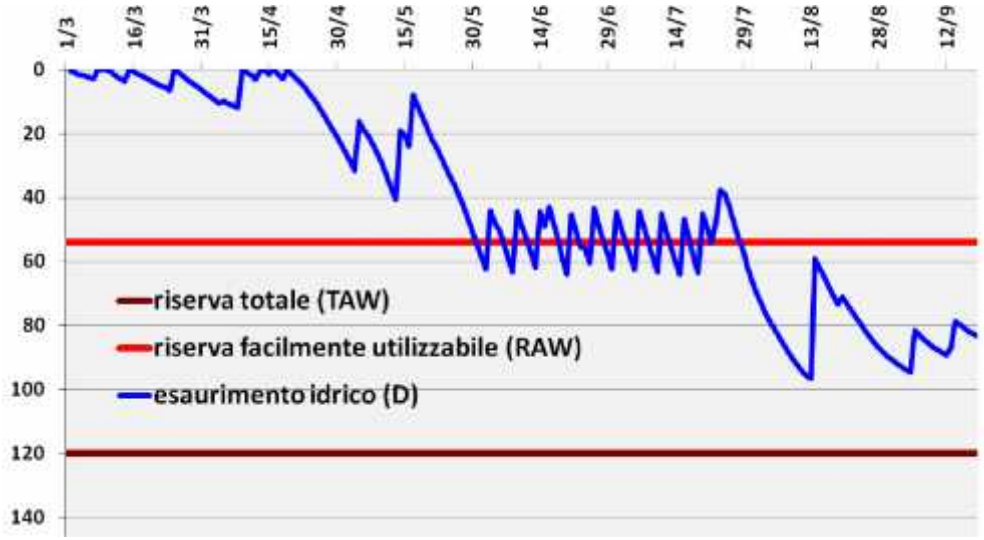
- For the determination of soil moisture, **several methods** are available (tensiometric, neutron-attenuation, resistance, heat dissipation, psychrometric, dielectric).
- Novel types of sensors based on the **measurement of soil dielectric properties**, have opened new possibilities for irrigation scheduling and incorporated them into **automated irrigation control systems** (Jones, 2008; Pardossi et al., 2009).
- The main advantage is that the **records**, to consider the 'feedb keeping the soil water statu modulating the irrigation amour
- The assessment of the effec **irrigation systems** could be diffi sampled in the root zone (the use of large sensors arra limited by the cost).

# (1) Introduction

- **Crop-soil water balance calculation**

| Methods | Advantages | Disadvantages |
|---|---|---|
| **Formulas to calculate evapotranspiration** (e.g. Penman-Monteith, Hargraves-Samani), **soil water balance, simulation models** | Weather measurements normally available; **relatively simple to apply**; calculate "how much" water to supply | Less precise that direct measurement methods; require local evaluation **of weather variables** and a good estimation of **crop-soil parameters** (e.g. Kc) |



- **Crop-soil water balance calculation**

- Examples of DSS for irrigation management at the field/farm scale, such as **CROPWAT** (Smith, 1992), **AQUACROP** (Steduto et al., 2009), **CROPIRRI** (Zhang and Feng, 2010), **MODERATO** (Bergez et al., 2001), **PLANTE-INFO** (Thysen and Detlefsen, 2006).
- This method has the advantage to **link irrigation requirements with weather conditions**.
- It requires an **appropriate selection of crop-soil parameters**, which could be sometimes generic resulting in an inaccurate parametrization of the model.
- Practical model-based DSS can be used: i) to set different **irrigation scheduling strategies**; ii) to consider some important **constraints** related with irrigation; iii) to be entirely **web-based (internet)** in terms of inputs, automatic acquisition of weather data and consultation of irrigation advices.