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MADRID, SPAIN
26-28 JUNE 2024

Spanish National Research Council (CSIC)

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ICEX

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GOBIERNO DE ESPAÑA · MINISTERIO DE AGRICULTURA, PESCA Y ALIMENTACIÓN

TITLE: Improving irrigation efficiency in olive orchards facing droughts

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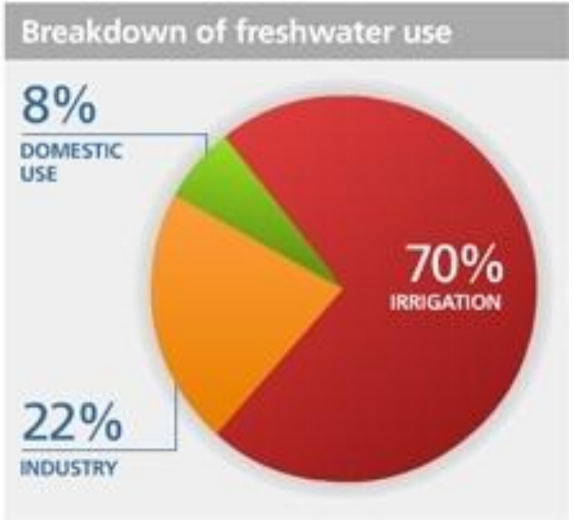
Introduction

- Water resources are under pressure due to:
  - rapid increase of world population
  - extension of irrigated land
  - industrial development
  - climate change



- Currently
  - agriculture use more than 70% of water globally
  - irrigated land have increased 6fold since 1900: 40 Mha in 1900 →260 Mha in 2000 and is increasing ….
  - 40% of world food production comes from 18% of irrigated agriculture
- To overcome the shortage of water in agriculture it's necessary:
  - To increase the water use efficiency
  - To use the low quality waters (saline, reclaimed, drainage waters

Water and olive growing

More than 90% of olives are cultivated in Mediterranean Basin countries, in which the impacts of climate change are more dramatic due to intense competition for natural resources (water and land) between agriculture and other economic sectors.

Olive culture in Mediterranean

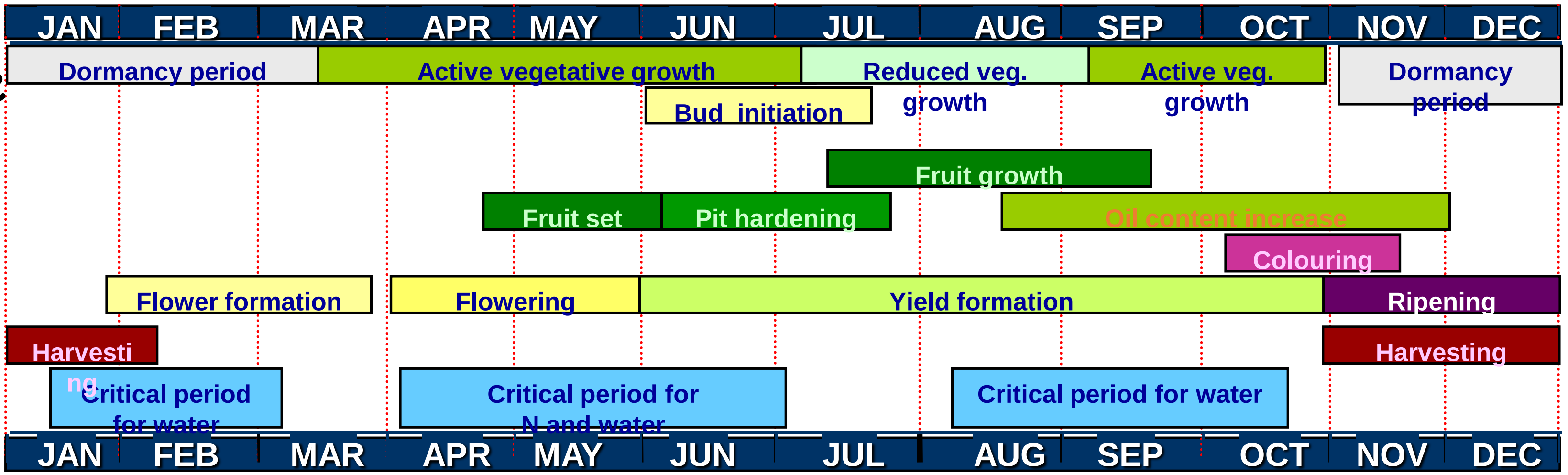
- Annual rainfall: ranges from 200 to 1000mm
- Good vegetative growth
  High yields ⇨ 500 – 600 mm

- In this region insufficient rainfall can lead to water stress and impact the overall health and productivity of the olive trees.
- Irrigation is required :
  - In olive orchards with rainfall less than 400 mm
  - New intensive and super-intensive plantations (280-1800 plants/ha)
  - In poor soils with low water holding capacity

Water and olive growing

Changes in precipitation patterns and the increasing drought periods increases irrigation needs pose significant threats to the overall viability and sustainability of olive groves.

Although olive is not a water-demanding crop like avocados and citrus, not all growth stages are equally resistant to water, and combinations of the duration and level of water stress are important.



The flowering, fruit set and oil accumulation stages are the most sensitive to water-stress conditions.

Water and olive growing

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Considering the above, but also the economic, social and environmental role of olive cultivation in the Mediterranean countries, the challenges for both research and technology are among others to improve the sustainability and competitiveness of olive cultivation in terms of water management and adaptation to climate change.

The research with the study, evaluation and highlighting of existing rich varietal potential of the olive in terms of resistance to drought, salinity and cold requirements in relation to the yield and quality of the olive oil produced. Technology with innovative practices will increase the efficiency of fresh irrigation water - more per drop-, but also the utilization for irrigation of low quality waters (saline, treated and drainage water).

Rainwater harvesting and storage techniques can play also a crucial role in sustainable irrigation practices, particularly in regions where rainfall is erratic or insufficient.

Irrigation methods

Innovative irrigation techniques to improve irrigation efficiency
Shift from the gravity irrigation to modern pressurized networks

Localized versus Traditional methods

Traditional surface irrigation methods (basin, furrow, border, etc) must be abandoned because they

- Have low irrigation efficiencies: (40-50 %)
- Requires large discharges per unit area
- Are not suitable for supplemental irrigation
- Have high labor cost

Localized irrigation systems are:

-the most efficient in water saving.

-can be operated automatically and

-can be used to apply nutrients to the olive trees

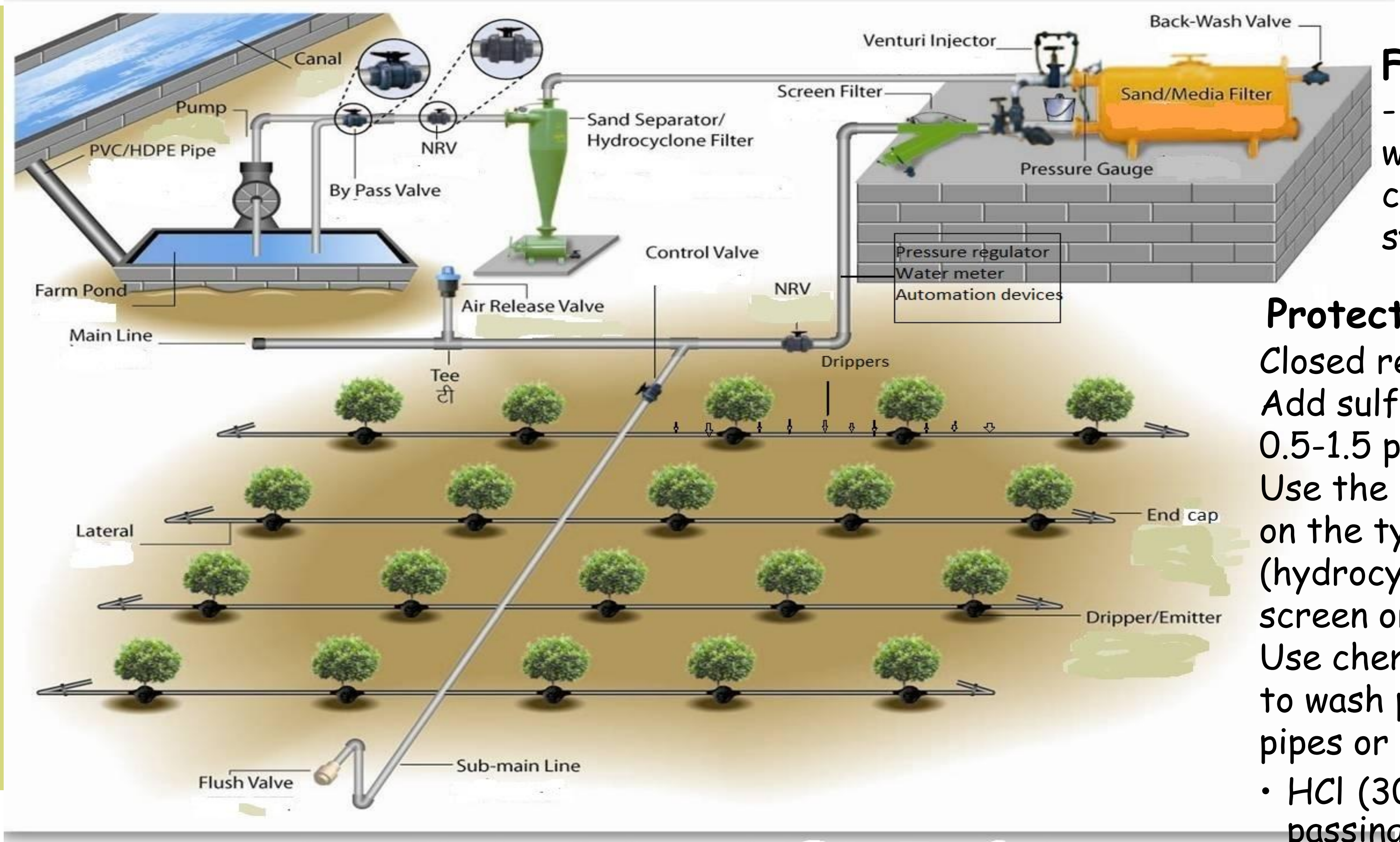
Micro-irrigation systems

- Micro-irrigation (trickle or drip irrigation) applies water to individual plants by means of plastic pipes, usually laid on the ground surface.
- Drip irrigation: water is slowly applied through small emitter openings from pipes, $q \leq 12$ l/h.
- Micro-sprayer (micro-sprinkler) irrigation: water is sprayed over the part of the soil surface occupied by the plant, $q > 12$l/h.

Drip irrigation improve conveyance efficiency, deliver water and nutrients directly to the root zone of olive trees and saves water and energy by reducing losses from tree transpiration, evaporation and surface runoff.

- Its efficiency can reach 95%. Disadvantages: Sensitivity to clogging
- High initial investment cost

Lay-out of a drip system



Layout of Drip Irrigation System

Filtration

- avoid emitter clogging, which reduces operational capability and life of the system.

Protection measures

Closed reservoirs wells, channels

Add sulfuric copper ($CuSO_4$) at 0.5-1.5 ppm

Use the proper filters, depending on the type of clogging material (hydrocyclone, gravel filters, screen or disc filters)

Use chemicals (HCL 30% or H3PO4) to wash precipitates inside the pipes or drippers

- HCl (30%) 4-6lt per m^3 of water passing through the system.
- Irrigate for a least 30 min.

Irrigation scheduling

Shift from the empirical irrigation to irrigation scheduling

Irrigation scheduling: decision-making process for determining when to irrigate and how much water to apply.

SOIL- CROP CHARACTERISTICS

- ⇨ soil – water storage capacity
- ⇨ infiltration rate
- ⇨ crop response to water
- ⇨ stage of development

MANAGEMENT OBJECTIVES

- ⇨ technical support of the farmers by extension offices experts

IRRIGATION SCHEDULING

CLIMATE

- ⇨ evaporative demand
- ⇨ rainfall amount and distribution
- ⇨ temperature

IRRIGATION PRACTICES

- ⇨ method of irrigation
- ⇨ water delivery systems
- ⇨ availability of water

Irrigation scheduling

Based on soil-water parameters

Soil electrical resistance

Soil water potential

Soil water content

Soil water content and potential

Remotely sensed soil moisture

Based on crop parameters

Leaf water content

Leaf water potential

Canopy temperature

Changes in diameter of stems and fruits

Sap flow measurements

Remote sensing of crop stress

Based on climatic parameters

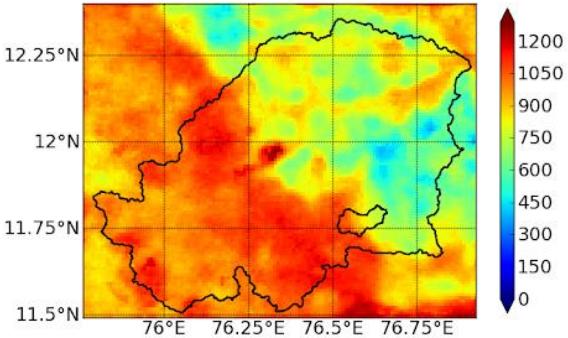
Pan evaporation plus rainfall data

Crop evapotranspiration (and rainfall)

ET measurements

Remote sensed ET

Penman – Monteith method (FAO 56)



Deficit irrigation

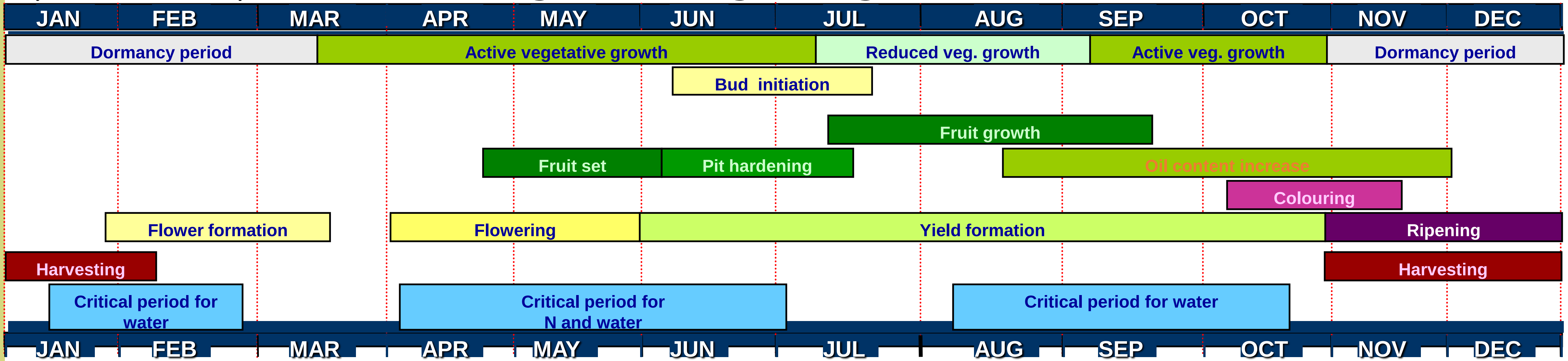
No limitations of the available water supply	⇒	Full crop requirements are given
Limitations of available water supply	⇒	Strategies not based on full crop water requirements must be adopted

Deficit irrigation (DI): the irrigation below full-water requirements by eliminating irrigations that have little impact on yield, aiming at the maximum production per unit of water applied.

Such techniques include regulated deficit irrigation (RDI), partial root drying (PRD) and subsurface irrigation (SSI) and can save up to 30% irrigation water.
The adoption of deficit irrigation implies appropriate knowledge of olive response to water deficits at the critical growth stages and need support to be implemented.

Regulated Deficit Irrigation (RDI)

The olive is exposed to certain level of water stress either during a particular period or throughout the growing season



Effect of irrigation treatments on water use, yield and water utilization efficiency (Chartzoulakis et al., 1992)

Treatment	Irrigation water (mm)	Fruit yield (kg/tree)	Oil content (% FW)	E_y (kg oil/mm H_2O)
Full irrigation	432	38.3 a*	21.3 a	0.49 a
Deficit irrigation	321	34.1 a	22.8 b	0.73 b
Rainfed	--	24.1 b	23.5 b	--

Partial Root Drying (PRD)

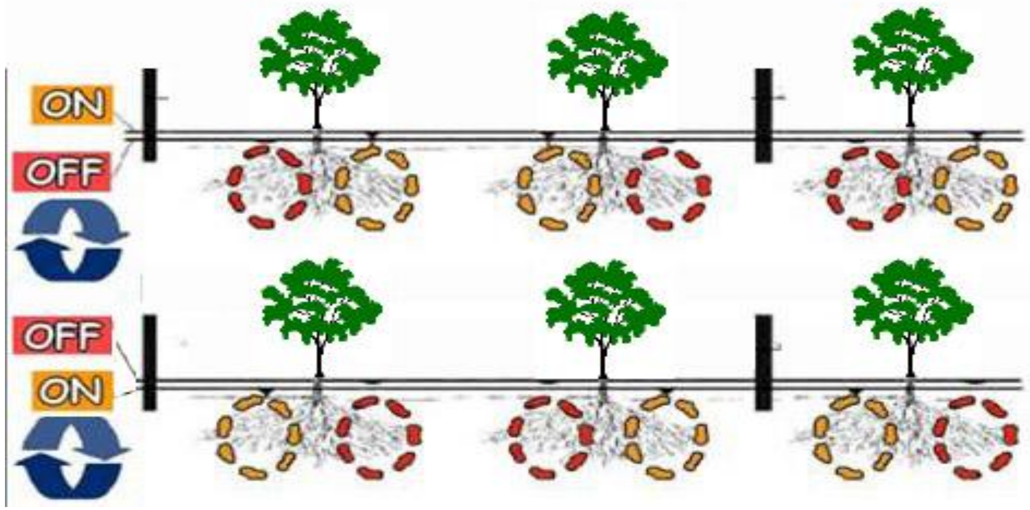
Irrigation technique to induce water stress in fruit trees

One part of the root system is subjected to dry or drying conditions, while the other half is irrigated.

Wetted and dried sides of the root system alternates on a 7-14 day cycle.

PRD uses biochemical responses of plants to water stress to achieve balance between vegetative and reproductive development

PRD improves production per unit of water.



Irrigation water is halved while no significant reduction on yield occurs

Cost:

- Varies according to the irrigation system employed
- In pre-existing irrigation systems an additional line is added
- In water scarce areas the true environmental cost of water justifies the cost of implementing PRD

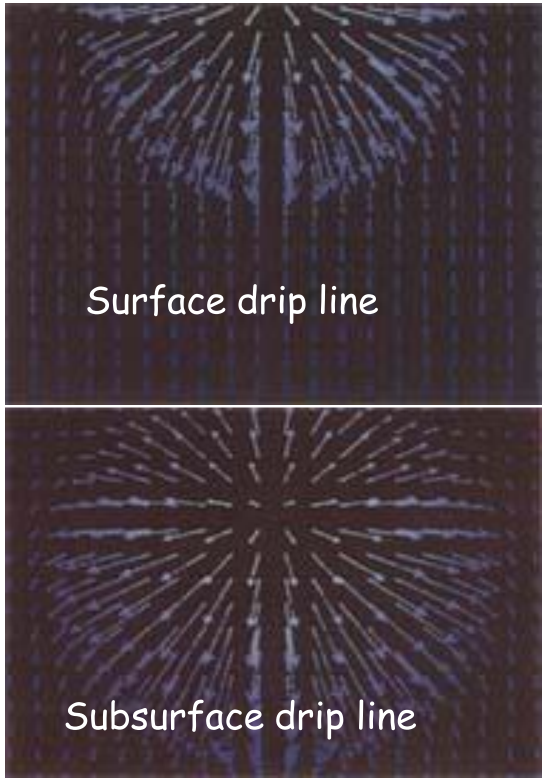
Irrigation systems used:

Drip irrigation (Centritto et al., 2005; Dhara et al., 2016; Fernandez-Silva A., 2020)
Subsurface irrigation (Tubeileh et al. 2017; Oregoni K. H. 2014)

Subsurface irrigation (SSI)

A low-pressure, low volume irrigation system that uses buried tubes to apply water

The applied water moves by soil matrix suction. Wetting occurs around the tube and water moves out in all directions



Materials

- A large variety of tubes are available on the market
  - PE tubes with built-in emitters
  - Porous tubes ooze water out the entire tube length

Placement

- The tube is injected below the soil surface by special device pulled by a tractor
- Depth of installation: depends on soil: 30-50 cm for olives
- A 200 mesh filter is adequate for most tube material
- Water quality affects the system (high pH, salinity and iron will cause precipitates)

Fertigation

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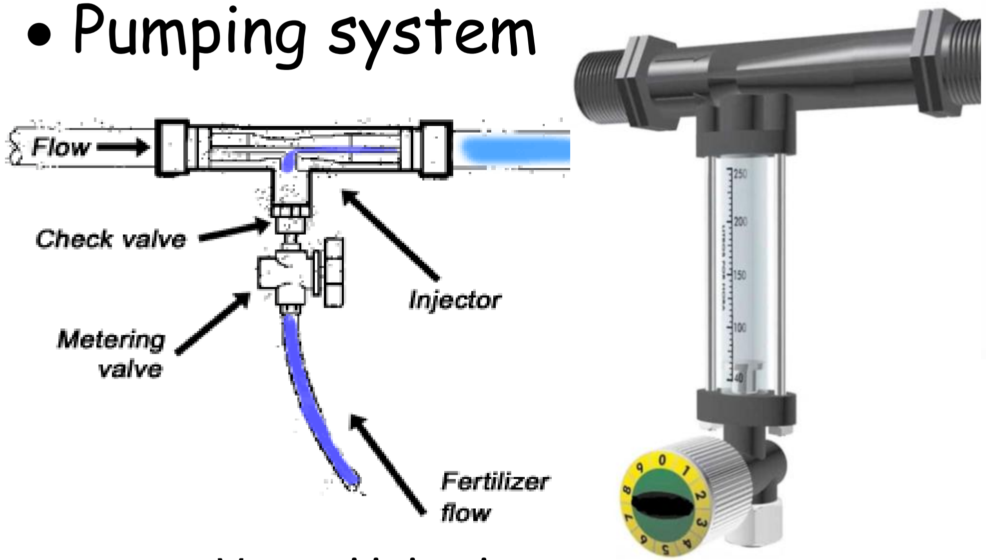
The application of fertilizers through the irrigation system.

- Precise amount at the root system
- Optimum conditions for use
- High fertilization efficiency
- Flexibility in timing of fertilizer application
- Environmental friendly

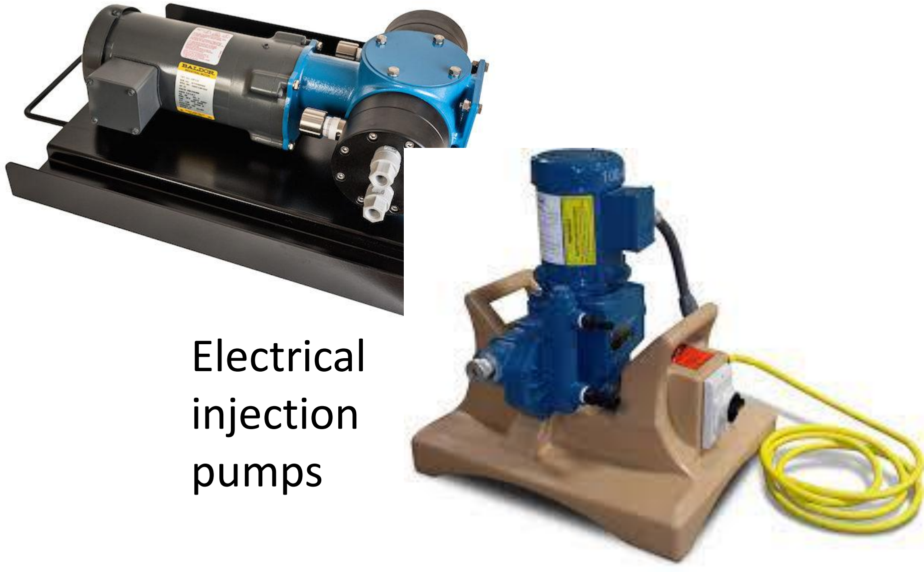
Fertilizer injection

- Differential pressure
- Pumping system



Venturi injection pumps

Hydraulic injection pump

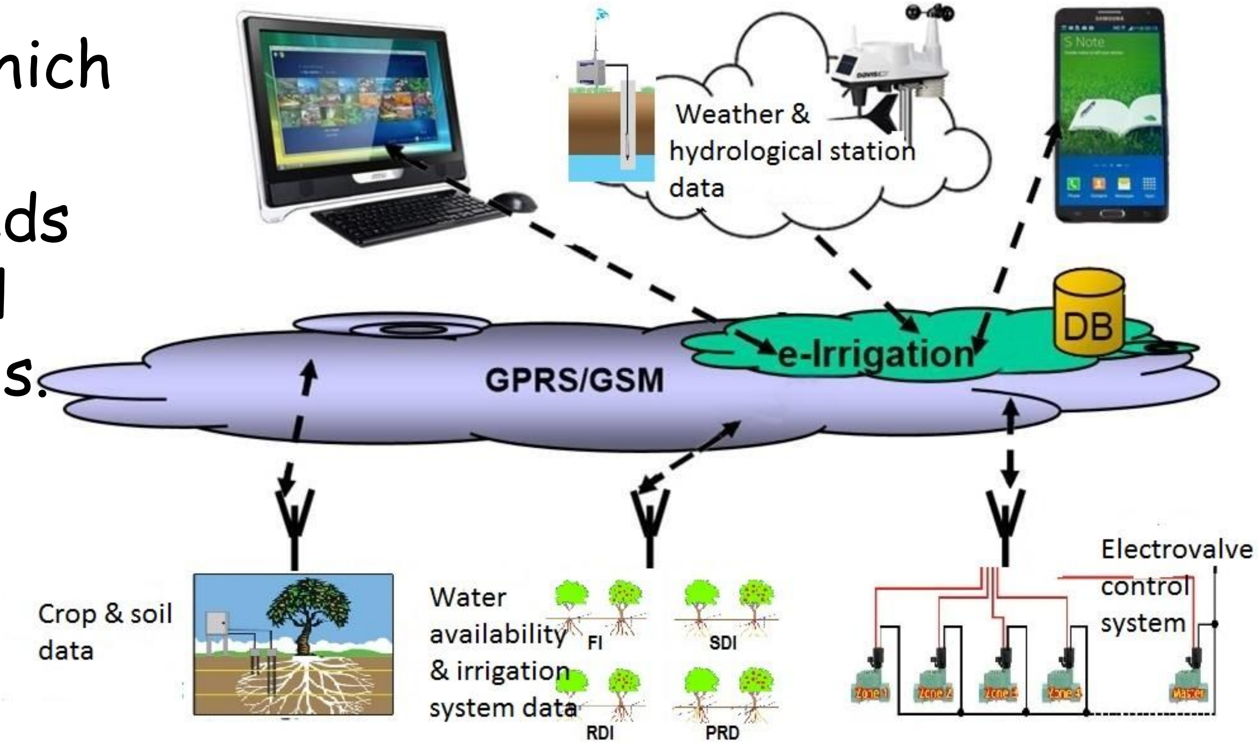


Electrical injection pumps

Precision irrigation (PI)

A new frontier for optimizing the use of irrigation water in olive groves

The use of technologies, like GIS, soil moisture sensors and remote sensing, which allow farmers to tailor their water and nutrient applications to the specific needs of different parts of their fields in real time, optimizing input use and crop yields.

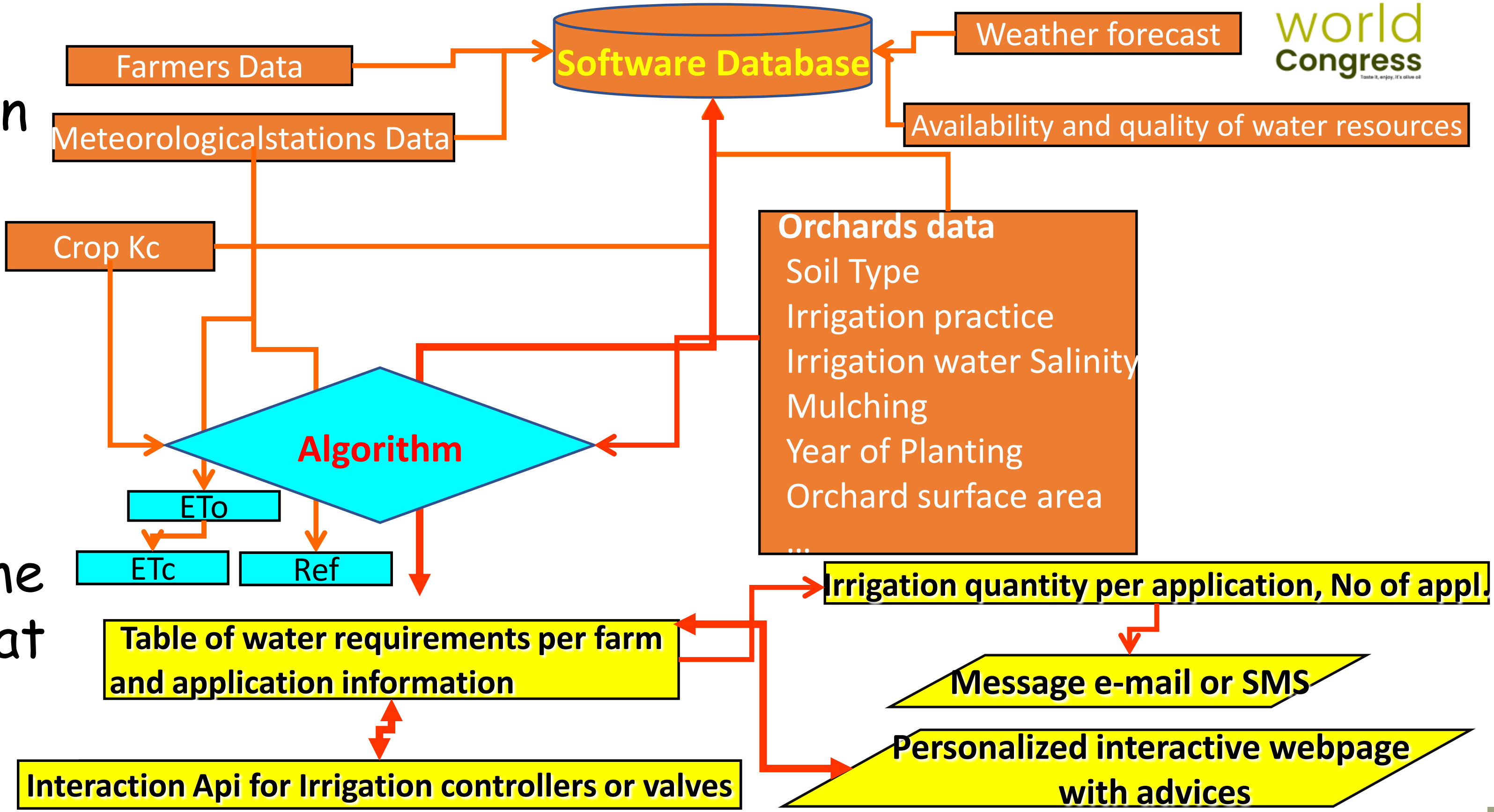


The artificial intelligence (AI) and machine learning algorithms can also play a significant role in improving water efficiency.

By integrating diverse data sets, from soil and weather conditions to olive characteristics, water quality and availability, irrigation system and mulching etc, these algorithms can provide farmers with sophisticated decision support tools. The decision (how much water and when to apply) is communicated to farmer's smart phone and/or directly to smart electrovalves for irrigation.

Precision irrigation (PI)

- ✓Farmer can interact with the software by recording irrigation applications.
- ✓The software can interact with solenoid and smart electrovalves.
- ✓No farmer intervention.
- ✓Inform farmer to protect the crop against extreme weather events (heat wave, frost).



The use of satellite imagery and drones on large olive groves can provide detailed information about olive health and water needs, enabling precise and timely interventions. This not only improves water and nutrient use efficiency but also enhances pest and disease management, further boosting olive productivity.

Use the saline waters

- Olive is considered as a moderately salt tolerant plant

Tolerance to salt appears to be cultivar-dependent

	Cultivar	Country	Source
Tolerant	Megaritiki, Lianolia Kerkiras, Kalamata, Kothreiki	Greece	Therios & Misopolinos 1988; Chartzoulakis *et al.*, 2002
	Frantoio	Italy	Tattini *et al.*, 1992; 1994
	Arbequiña, Picual, Jabaluna, Nevadillo, Lechin de Sevilla, Cañivano, Esscarabajuelo	Spain	Benlloch *et al.*, 1994; Marin *et al.*, 1995
	Hamed, Chemlali	Tunisia	El-Sayed Emtithal et al., 1996; Bouaziz 1990
Moderately tolerant	Amphissis, Koroneiki, Mastoidis, Valanolia, Adramitini	Greece	Therios & Misopolinos 1988; Chartzoulakis *et al.*, 2002
	Maurino, Coratina, Carolca, Maraiolo	Italy	Briccoli *et al.*, 1994;Tattini *et al.*, 1994; Bartolini *et al.*, 1991
	Aggezi, Mostazal, Toffahi, Wardan	Egypt	El-Sayed Emtithal et al., 1996
	Nabali Muhassan	Jordan	Al-Absi *et al.*, 2003
Sensitive	Chalkidikis, Throubolia, Aguromanaki	Greece	Therios & Misopolinos 1988; Chartzoulakis *et al.*, 2002
	Leccino	Italy	Tattini et al., 1994
	Bouteillan, Nabal	Egypt	El-Sayed Emtithal et al., 1996
	Pajarero, Chetoui, Calego, Cobrancosa	Spain	Marin *et al.*, 1995

Irrigation water quality guidelines for olives

Irrigation problem	Degree of problem		
	None	Increasing	Severe
Salinity			
Ecw (dS/m)	< 2.5	2.5 – 5.5	> 5.5
Specific ion toxicity			
Sodium (g/l)	0.25	0.3 – 1.0	> 1.2
Chloride (g/l)	0.35	1.4 – 1.5	> 1.8
Boron (ppm)	1 - 2		

Generally is accepted that high salinity (> 4dS/m) reduce olive yield

Salinity accelerate ripening process, increase phenol content, decrease unsaturated/ saturated ratios fatty acids.

Management practices

- proper irrigation scheduling
- efficient leaching (amount and timing)
- proper irrigation method
- blending of irrigation water of different quality
- use water of soil amendments

Reuse of reclaimed waters

A dynamic and cost-effective solution for the supply of irrigation water in water-scarce olive-growing areas is the use of treated wastewater (WWW) from wastewater treatment plants. It contains, among others, essential nutrients for the growth and good production of olive trees, such as nitrogen, phosphorus and potassium.

In EU countries the existing legislation sets the conditions for their use (Water Reuse Regulation).

Experiments with different cultivars confirmed that there is no negative effect on the growth and productivity of olive trees irrigated with TWW, as well the quality of oil produced (EVOO)

Segal et al. (2011) cv 'Barnea': no adverse effects on growth and yield

Bedbabis et al. (2010), cv 'Chemlali': no adverse effects on oil quality (chemical & sensory)

Palese et al, (2009), cv Maiatica: no fruit contamination, if are harvested from the tree.

Reclaimed water guidelines for olive irrigation

Parameter	Suggested values
pH	6 - 9
EC	< 3.0 dS/m
Suspended solids	< 30 mg/l
BOD	< 35 m/l
Faecal coliforms	< 200/100ml
Clorine	> 1 mg/l
Nematods	< 1/1

Thank you!

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