Research group AGR-268

Urban greening & biosystems engineering

Naturib

Influence of different variables on living wall irrigation

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Who we are

- Research group from the University of Seville
- Working on Living Walls (LW) since 2007
- 3 prototypes for research
- Three patents related to LW
- Several commercial LW in collaboration with terapia urbana

Who we are

Example of projects involving LW:

- Irrigation and lighting systems for LW
- Active LW biofilter & cooling system
- Influence of LW in indoor temperature
- Substrate analysis for LW
- Aquaponics
- Leonardo transfer of innovation

Introduction

- Completely different from a conventional irrigation.

  Distinctive Features:

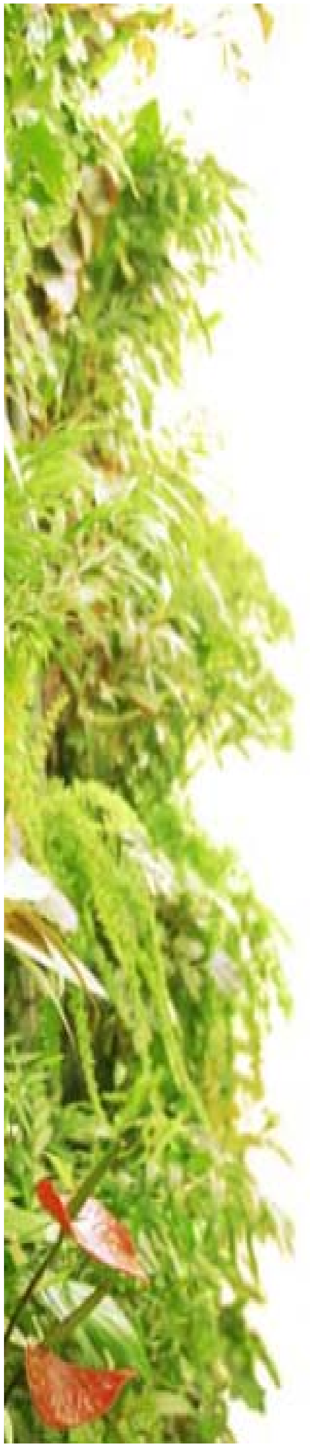
  - Vertical movement of water
  - Percolation = runoff
  - Prevalence of elevation over head losses
  - Mixture of localised and surface irrigation

- Difficulty for adapting to species with different water requirements: problems to establish hydrozones

- Design highly dependent on the LW system used

Introduction

- System completely vertical → low water storage capacity (especially in cloth)
- Only water retained by the substrate is available for plants → kept permanently wet
- Irrigation requirements highly variable depending on several factors:
  - location (outdoors or indoors)
  - light exposition (direct sun light, shading…)
  - temperature and humidity conditions
  - functional type (passive or active)
  - vegetation and substrate used
- Example: water consumption of an indoor PLW → 3 to 5 l m^{-2} day^{-1} over the warm season in southern Spain (Fernández-Cañero et al. 2011)



Introduction

Water use

Lost solution
('Run to waste' systems)

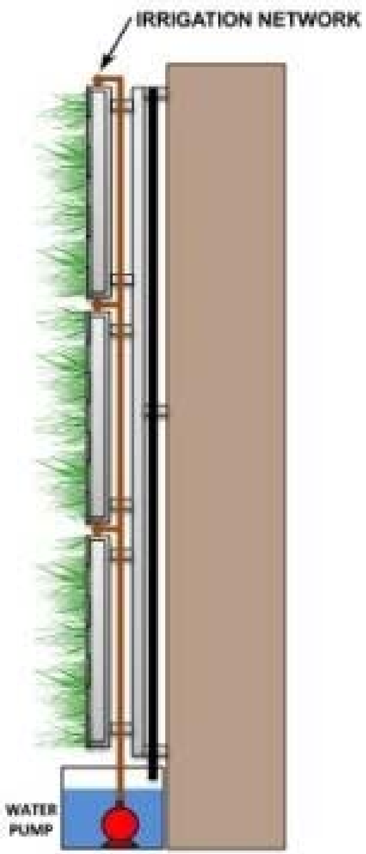
Recirculation systems:
reduce water losses and simplify irrigation scheduling, but require a more complex infrastructure.

Type of living wall

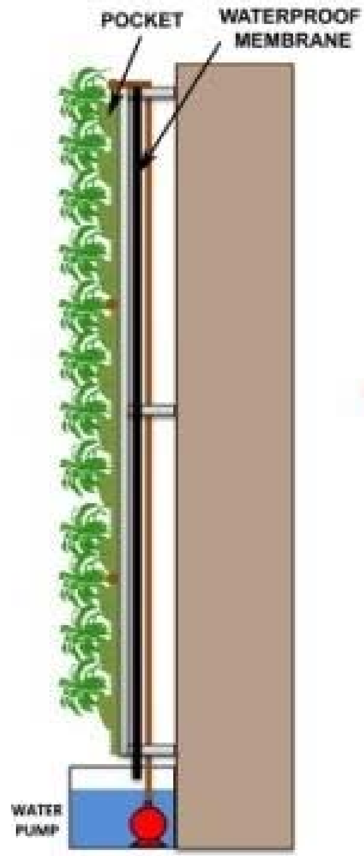
Green facade
Passive LW
Active LW

Indoor
Outdoor

Introduction



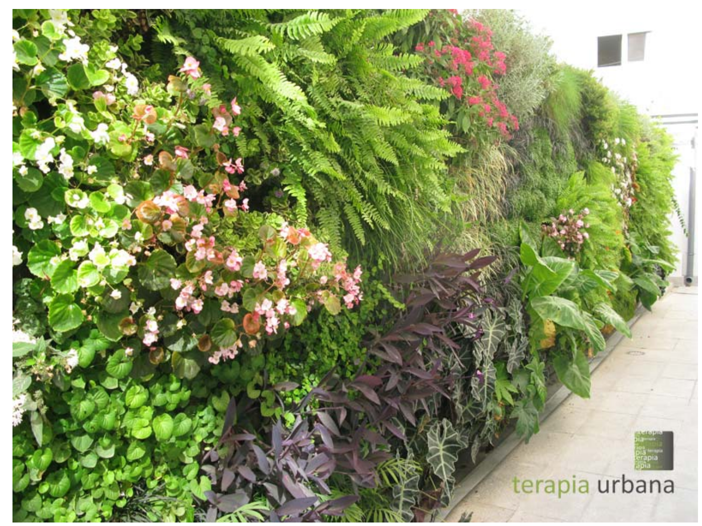
PANEL SYSTEM



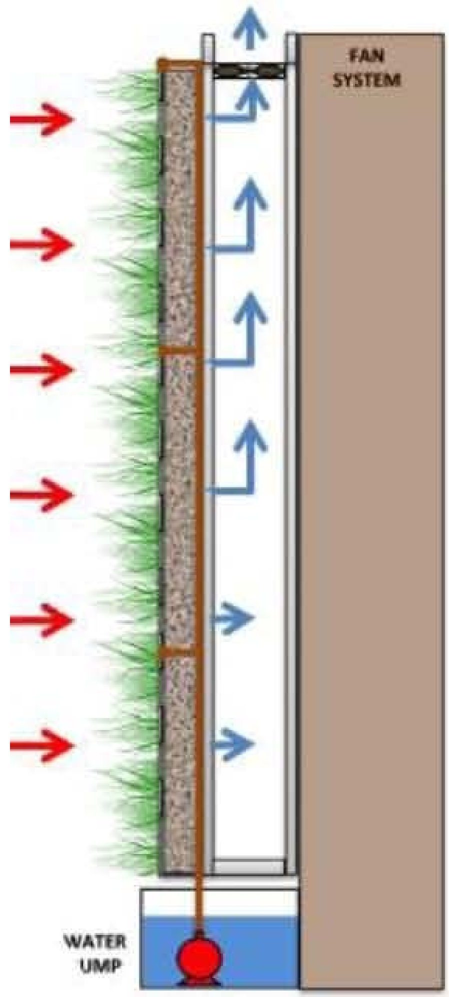
CLOTH SYSTEM

- Panels
  - Irrigation for each panel
  - Higher water retention capacity
  - More lateral diffusion: broader wetted area

- Cloth
  - More emitters density
  - More vertical water flow



Introduction



Active system

- Higher flow requirements
- Nozzles can be installed inside the structure
- Substrate with very low water retention capacity
- Higher irrigation frequency
  (the substrate dries out faster)

Introduction

- Several ways of applying water, most common → drip lines at different heights → water can move vertically and laterally in-between lines by gravity and lateral diffusion
- Design variables: emitters and drip line spacing and emitter type and flow
- Operational variables: irrigation duration and frequency, depending on:
  - type of living wall (indoor/outdoor, passive/active)
  - system design variables
  - environmental conditions (sunlight exposition, evapotranspiration…)
- <u>Challenge:</u> achieving a high degree of water **uniformity** in the entire wall while minimizing **water losses**

Introduction

• **Objective:** analyze different configurations of a recirculating irrigation system on two synthetic substrates

Design variables to be studied:

- emitter and drip line spacing
- emitter flow

• Determination of optimum duration of an irrigation event in terms of water distribution uniformity and water losses

Methodology

• Tested substrates: several synthetic textile sheets with a reduced thickness

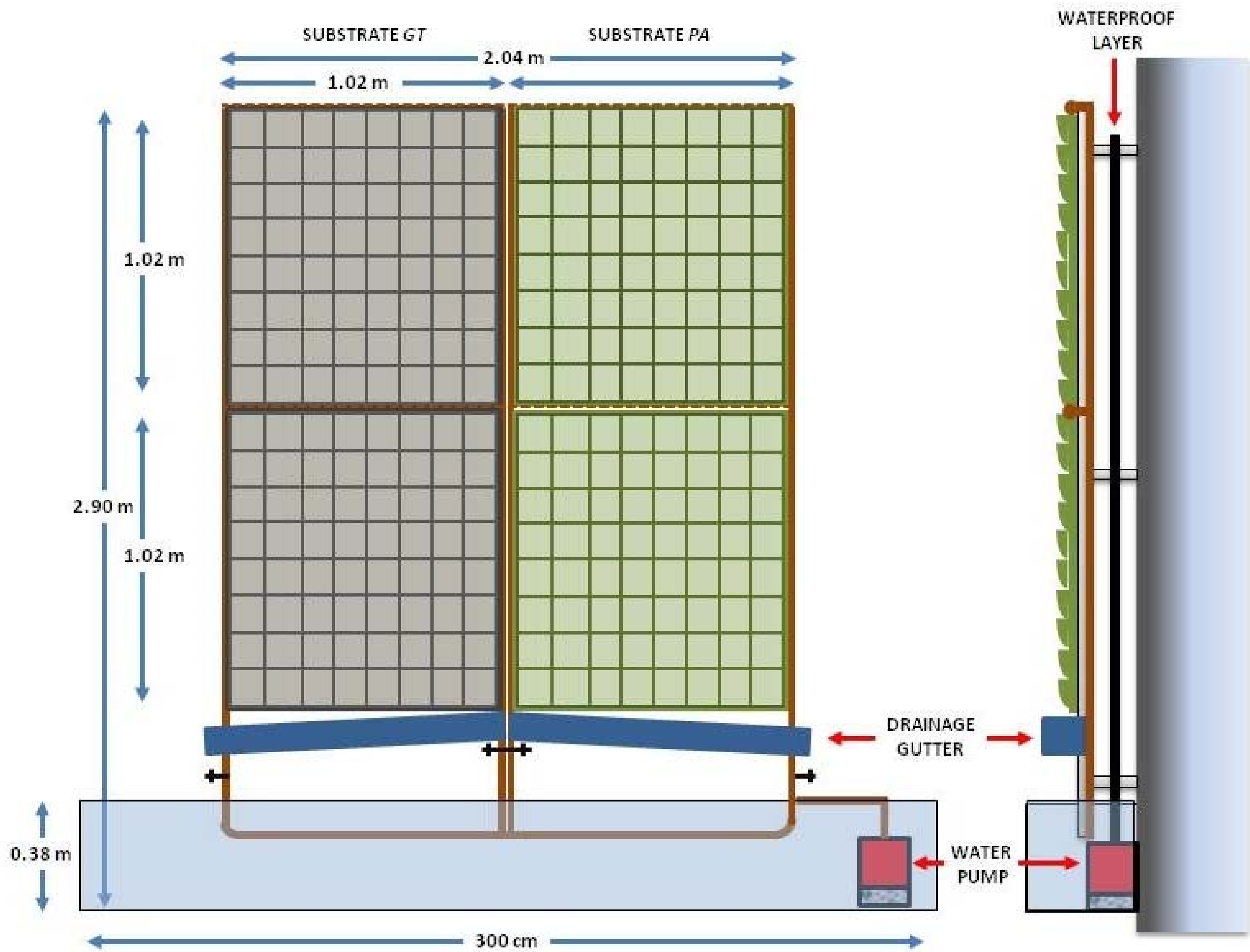
- Inner layers → homogeneous distribution of water and nutrients
- External layers → promoting the aeration of the plant root zone

• Sheets sewn together forming a grid of pocket-shaped containers of 0.12 m by 0.12 m where the root ball is inserted

• Geotextile (GT): acrylic textile made of different fibers with a polypropylene base, three sheets of 5 mm (commonly used in PLW)

• Polyamide - polypropylene (PA): 6 mm thick polyamide outer sheet + 10 mm polypropylene inner sheet. (commonly used for ALW)

Methodology



Test bench in the Urban Greening Laboratory (School of Agricultural Engineering, University of Seville)

Methodology

- Irrigation design variables
  - Three types of inserted pressure compensating button drip: J-SC-PC-Plus 2 l/h (NAANDAN®), Euro Plus 4 l/h and 8 l/h (TORO®)

Variable	Options			
Flow (l/h)	8	4	4-2*	2
Emitter spacing (m)	0.12 (standard)		0.24 (double -ds-)	
Line spacing (m)	1		2	
Substrate	Geotextile		Polyamide – polypropylene	

*Combination of 4 l/h (upper line) and 2 l/h emitters (lower line)

Methodology

- System performance assessment
  - Two tests: run-off losses and water distribution uniformity
  - Five replicates for each irrigation system configuration
  - Run-off test: measuring run-off rate (water collected at the bottom of the substrate every 30 seconds)
  - Uniformity test: evaluating the water distribution uniformity
  - Thermographic images every 30 s (thermal imaging camera PCE-TC 3, PCE Instruments, UK): resolution 160 x 120 px, sensitivity 0.15ºC

Temperature-based indicator: Moisture Index

$$MI_t = \frac{T_i - T_{min}}{T_{max} - T_{min}}$$

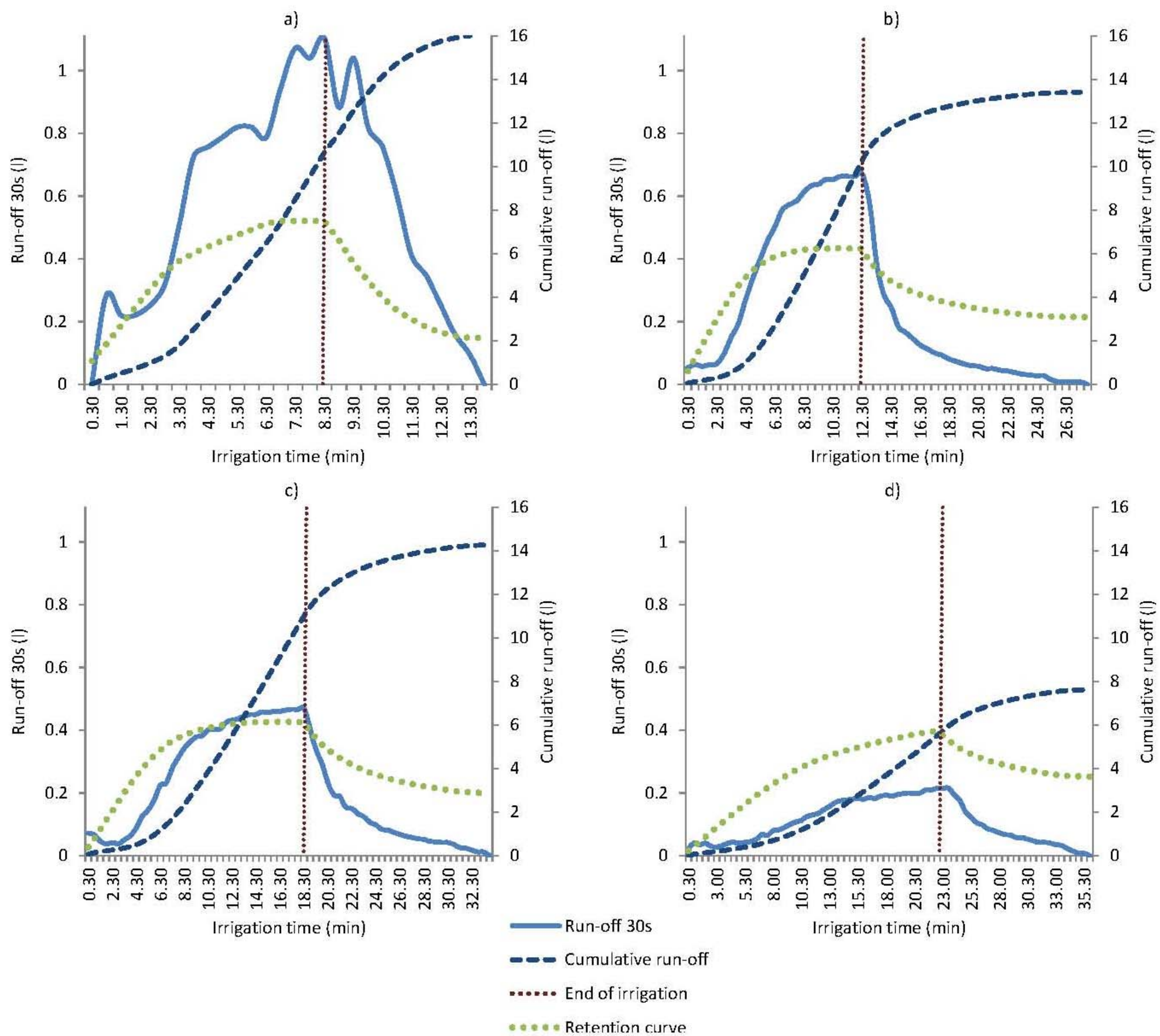
Methodology

- Irrigation event duration: determined for each configuration in a previous test. Irrigation stopped when run-off rate was constant

End of irrigation (minutes) for different flows and substrate materials

Flow	GT	GT(ds)	PA
8 l/h	8.5	14.5	6.5
4 l/h	12.5	19.5	5
4-2 l/h	18.5	-	4.5
2 l/h	22.5	33	3.5

Results



- Run-off test

  GT

  (a) 8 l/h

  (b) 4 l/h

  (c) 4-2 l/h

  (d) 2 l/h

Results

- Run-off test **GT**
- tendency towards lower retention values with higher flows
- 4 l/h and 4-2 l/h had a very similar performance
- less water retained when using double emitter spacing
- 2 l/h → lower run-off losses and higher volume of water retained

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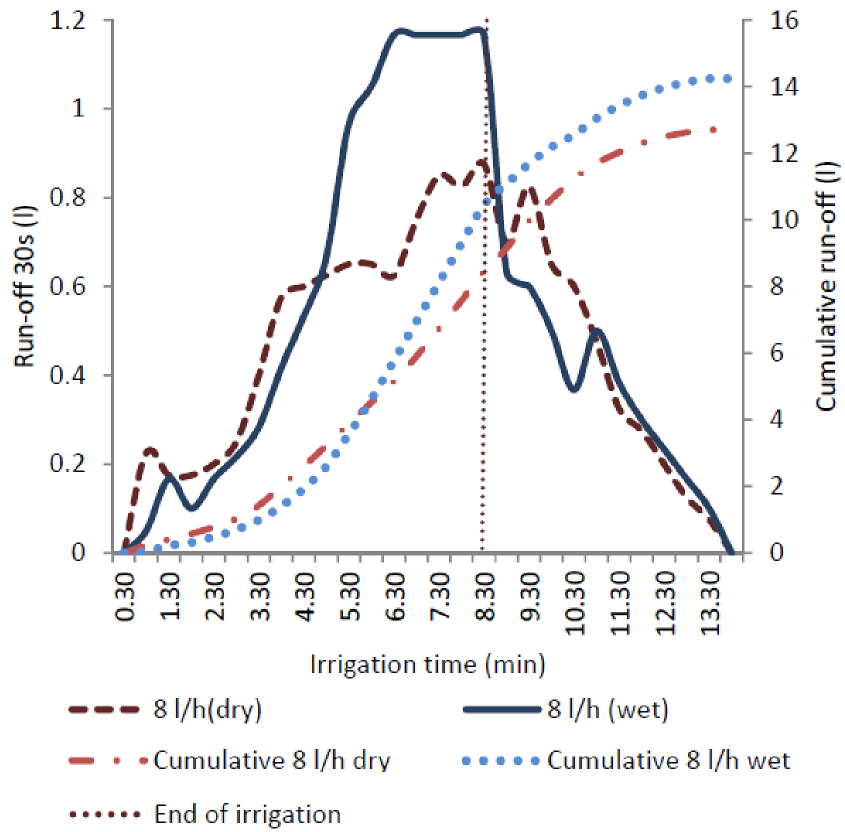
Results

- Run-off test **GT**

Effect of <u>initial moisture content</u>:

• Higher total run-off and peak value under initial wet conditions

• BUT during the first minutes of irrigation, run-off rate and thus water lost was higher under initial dry conditions



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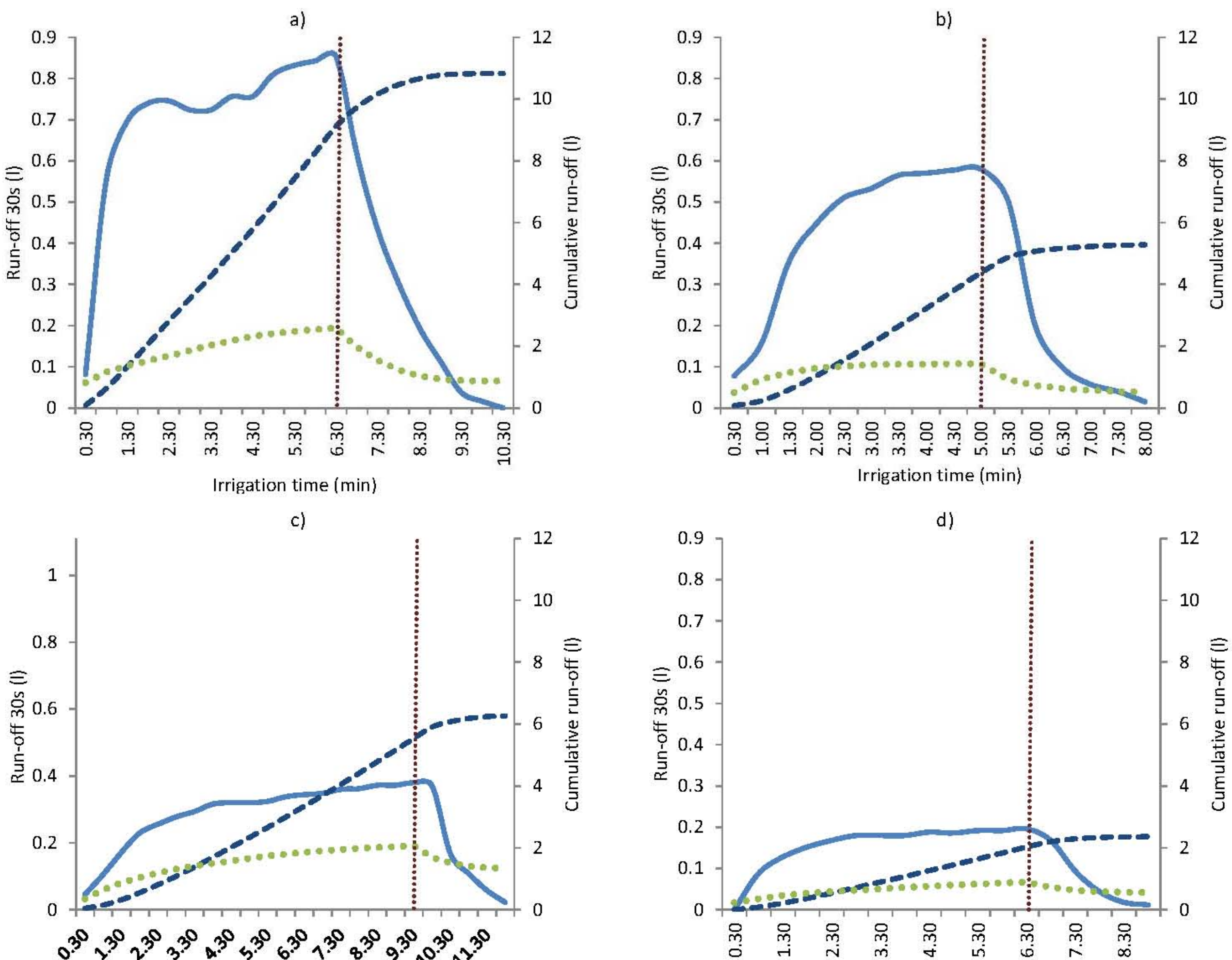
Results



- Run-off test

PA

(a) 8 l/h

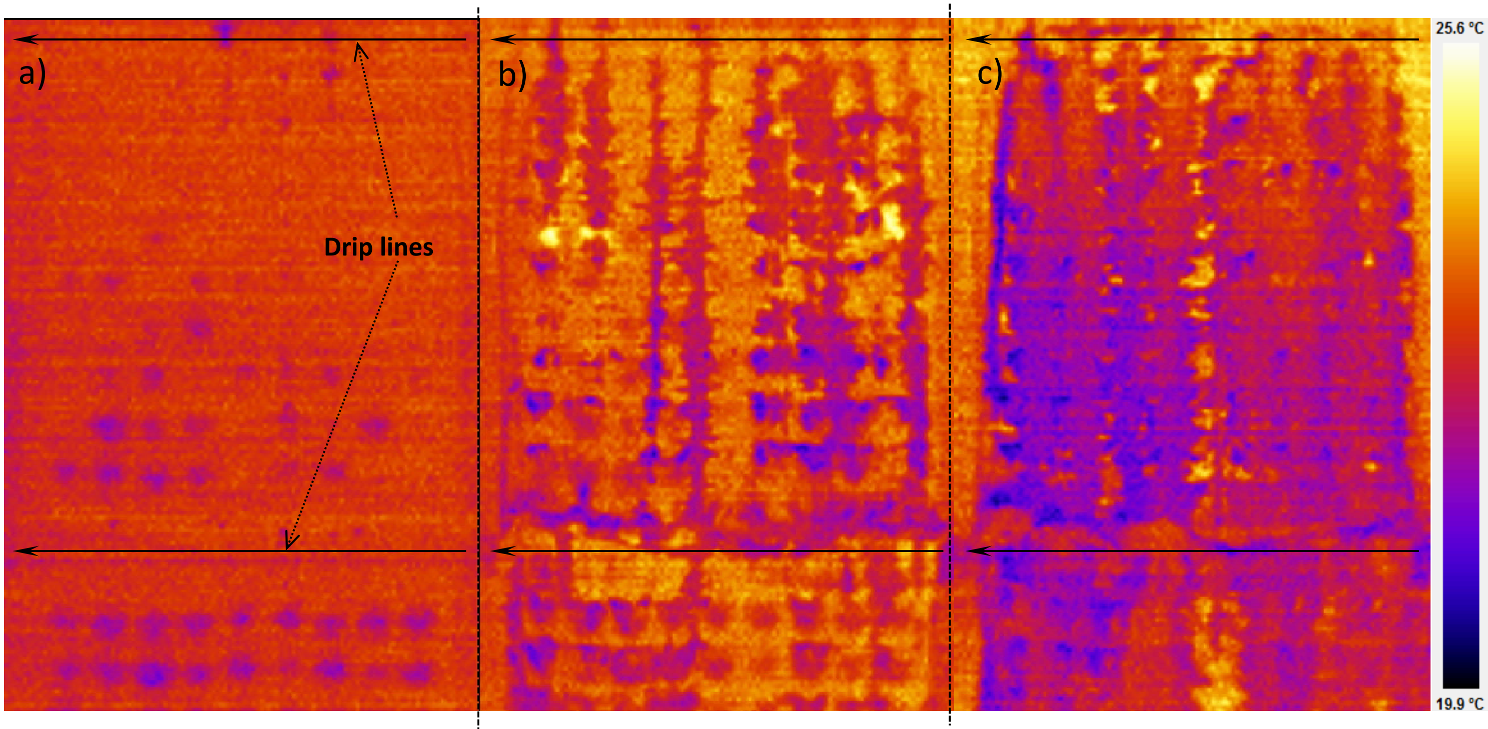
(b) 4 l/h

(c) 4-2 l/h

(d) 2 l/h

Results

- Uniformity test



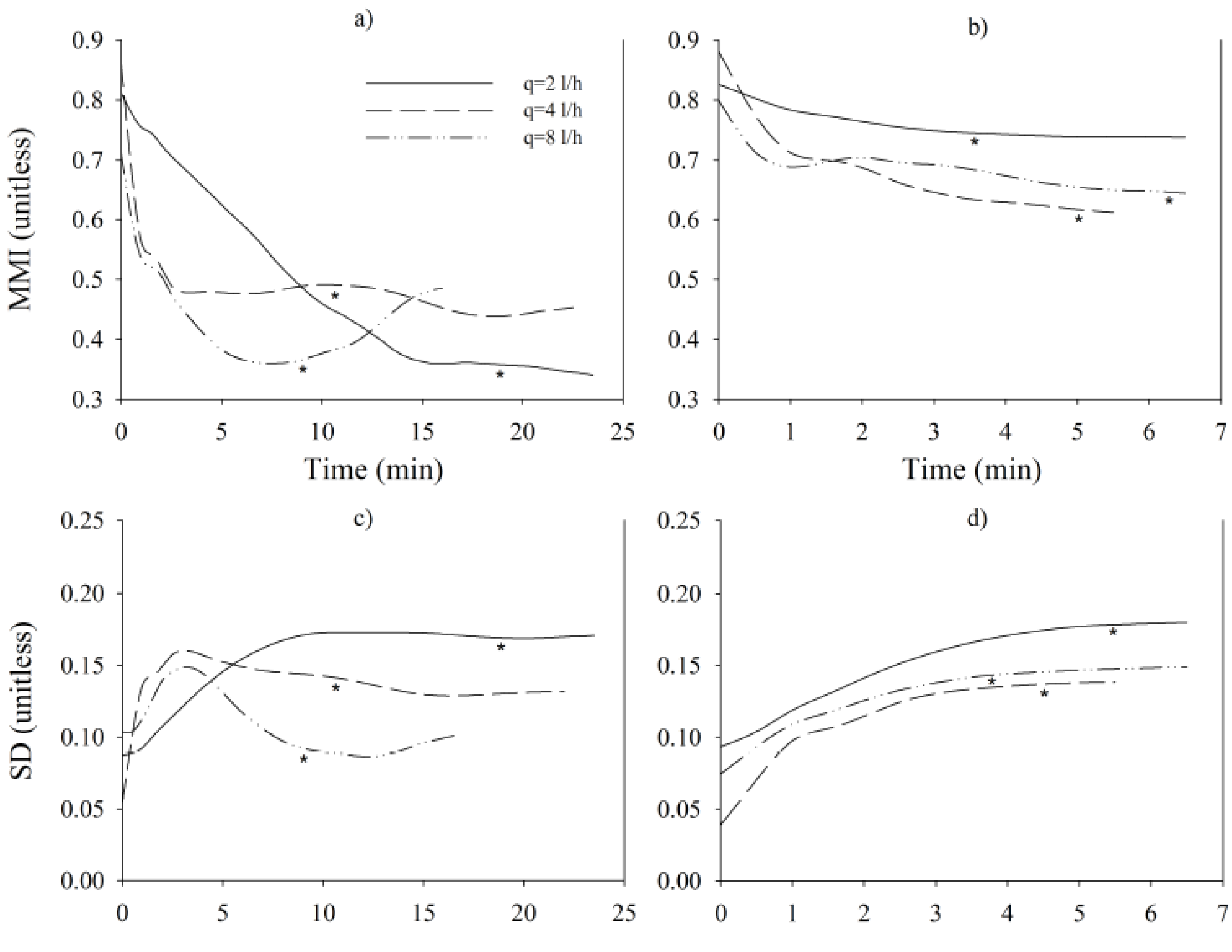
Example of a set of images taken for 4 l/h in GT before (a), during (b) and after (c) an irrigation event

Results

- Uniformity test

MMI values denote
r average moisture

SD values indicate
moisture variability
ss uniformity)



Results

- Irrigation event duration

  - Irrigation lengths used in this experiment, optimal in terms of water retention but not if run-off losses are considered → recirculation

  - Retention curve patterns showed an inflection point before reaching maximum duration

  - Shorter irrigation lengths are advised

  - Optimum times depend on slopes of cumulative run-off and retention curves, and water distribution uniformity attained (denoted by the MMI and SD curves)

Conclusions

1. Considerable differences between GT and PA substrates in terms of water retention and distribution uniformity
2. Difficulty to determine irrigation uniformity → Thermal imaging and MI as an indicator of the substrate moisture content
3. Distribution uniformity higher in the lower parts of the living wall → plan species selection (the lower section will retain more water)
4. When water is not reused, 2 l/h emitters with standard emitter and pipeline spacing (highest water retention capacity though less uniformity)

Conclusions

5. Double emitter or drip line spacing not advisable with 2 l/h
6. Recirculation systems → 8 l/h emitters installed on standard-spaced (1 m) pipelines: highest distribution uniformity
7. When using PA, only recirculation systems are recommended, 4 l/h
8. Good irrigation strategy: shorten the irrigation events by applying water when the substrate is still relatively wet
9. For larger living walls, pressure compensating emitters

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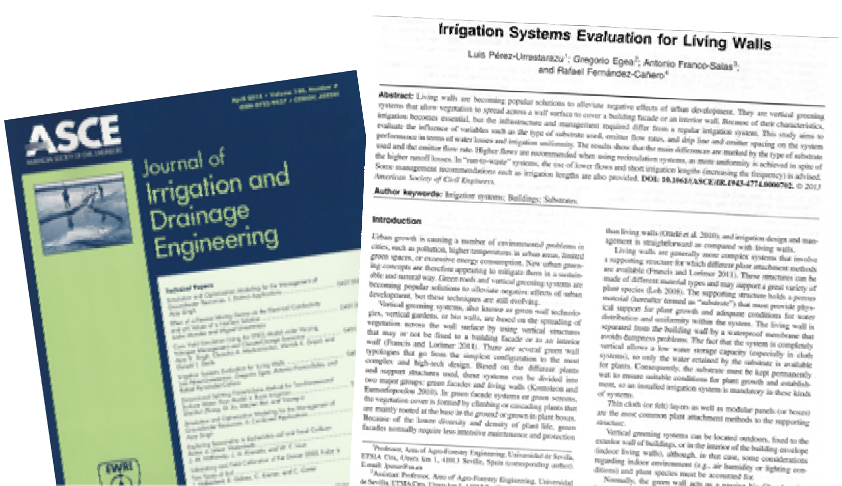
For more information:

Perez-Urrestarazu, Luis; Egea, Gregorio; Franco-Salas, Antonio; Fernandez-Cañero, Rafael. 2014. Irrigation systems evaluation for living walls. Journal of Irrigation and Drainage Engineering 140 (4): 04013024-1/11



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Thank you for your attention

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