MELISSA MICRO-ECOLOGICAL LIFE SUPPORT SYSTEM ALTERNATIVE

2022 MELISSA CONFERENCE

8-9-10 NOVEMBER 2022

CREATING A CIRCULAR FUTURE

Advancement of the PFPU Root Module for the production of tuberous species in microgravity

Palladino M., Pannico A., Duri L.G., Rouphael Y., De Pascale S.

Dept. Agricultural Sciences, University of Naples Federico II, Italy

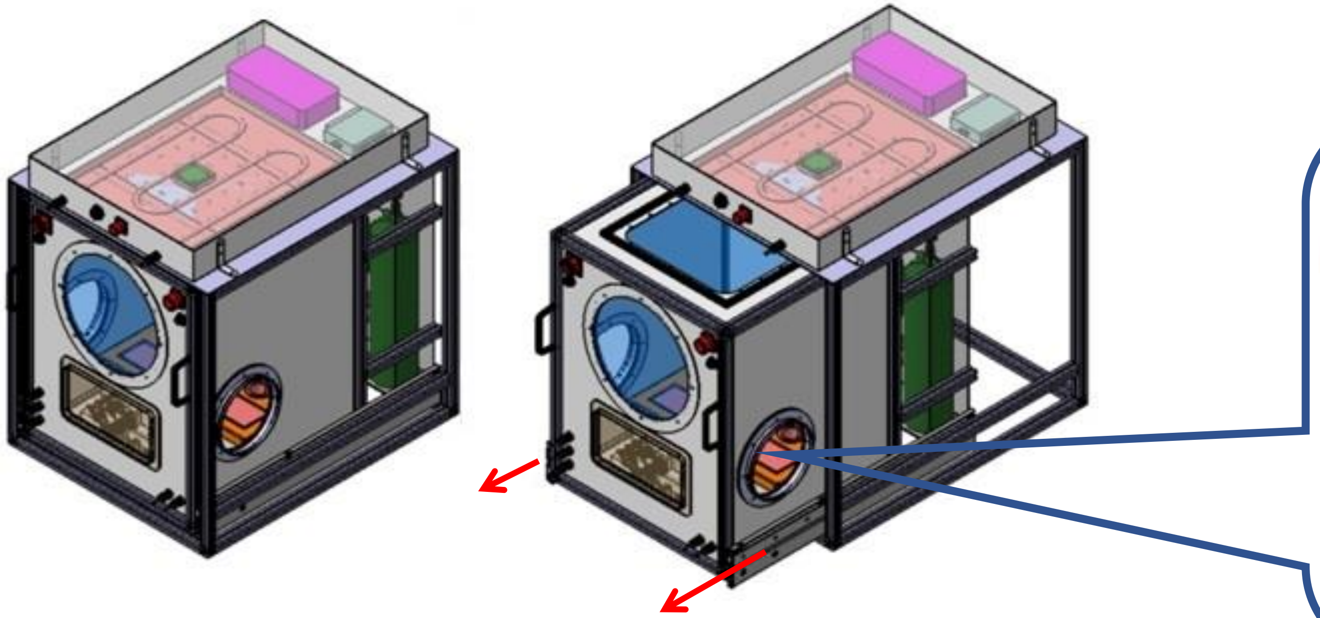
ThalesAlenia Space — A Thales / Finmeccanica Company

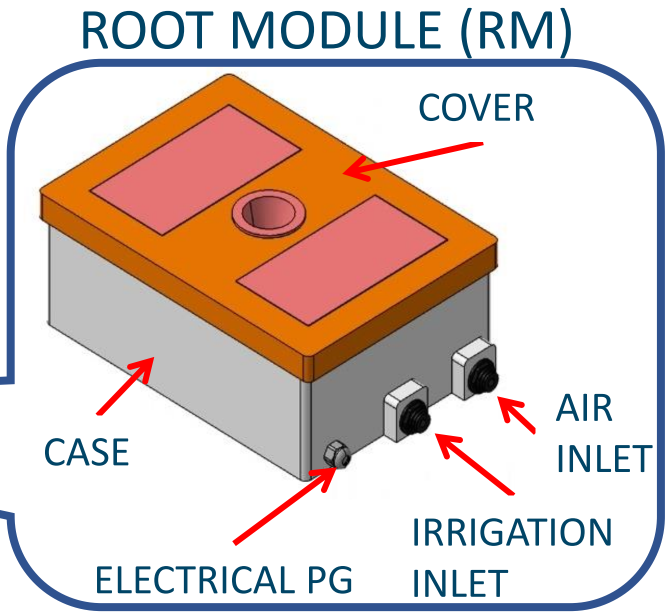
PFPU — Precursor of Food Production Unit

DIPARTIMENTO DI AGRARIA

ESA PRECURSOR FOOD PRODUCTION UNIT

Development of a Plant Growth Unit (PGU) prototype





Aims:

1) Potato production from tuber-seeds to ready-to-harvest tubers;

2) Able to operate in micro-gravity conditions (with minimum effort by crew members);

3) Highly modular, allowing compartmentalization into independent modules.

First phases of PFPU Project

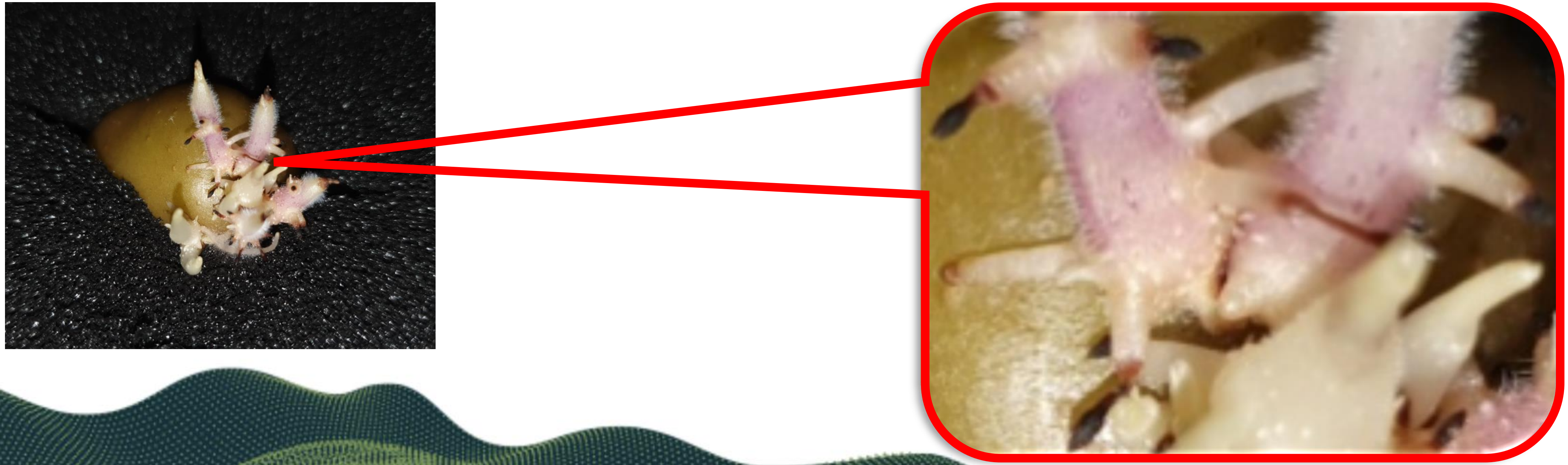
- Selection of substrates suitable for microgravity and hydrological characterization;
- Sensor's calibration and set-up of the water and nutrient delivery system;
- Cultivar selection (tuber-seeds sprouting and plant growth).

Polyvinyl Acetate (PVA) sponge resulted to be the best growth media also in terms of biological stability

Objectives

PROBLEM (from previous tests): High air relative humidity (RH) in the Tuber Zone (TZ) caused necrosis of the shoot apex and of the stolons.

CHALLENGE: appropriate management of air relative humidity in the Tuber Zone (TZ).



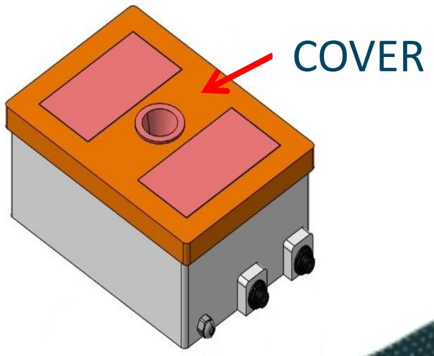
Preliminary Laboratory Tests

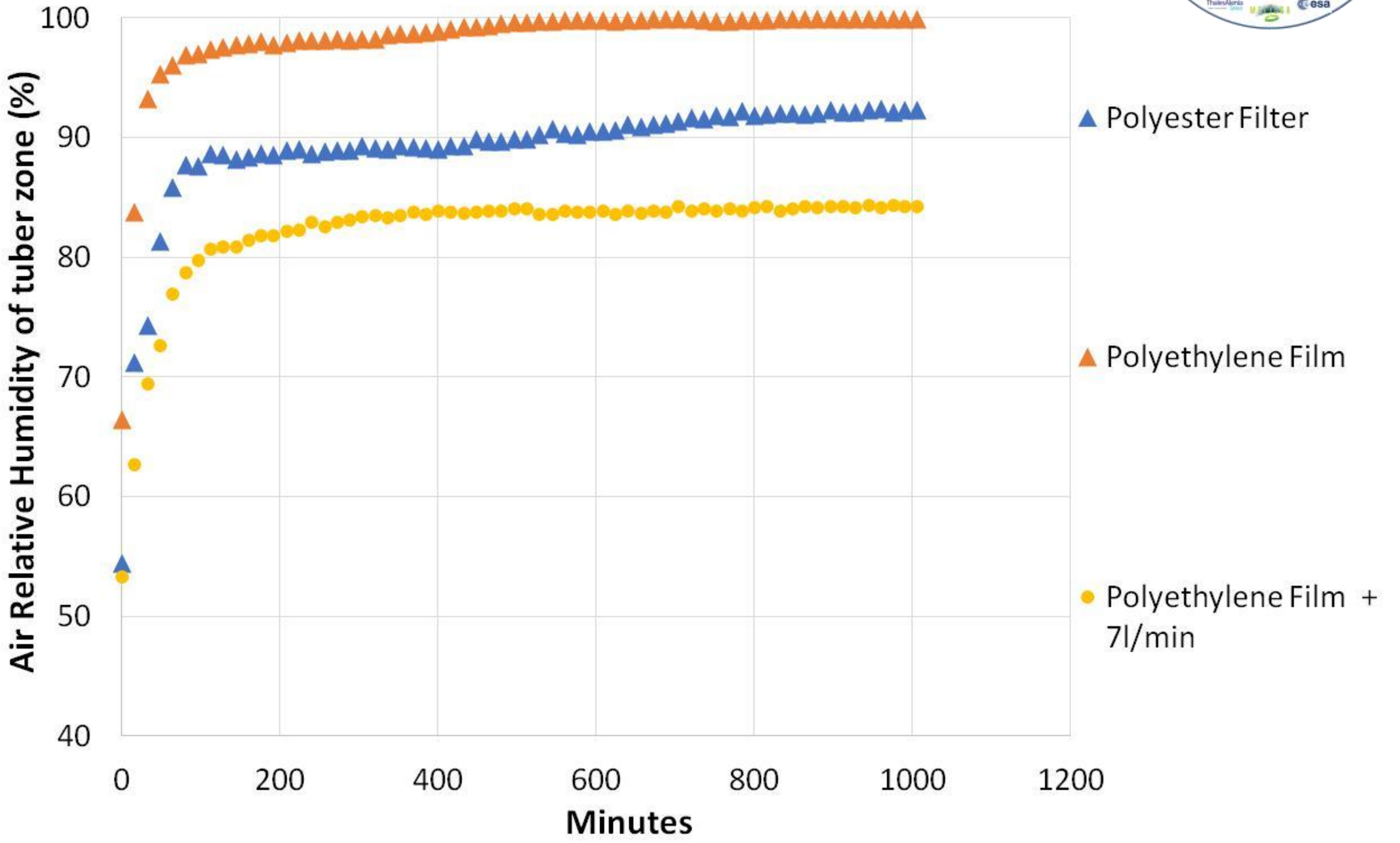
Polyethylene Film (light- and gas-proof)

Polyester Filter (light-proof but gas-permeable)

PE+AVS: PE plus an Active Ventilation System

AVS: 4L min^{-1} or 7L min^{-1}





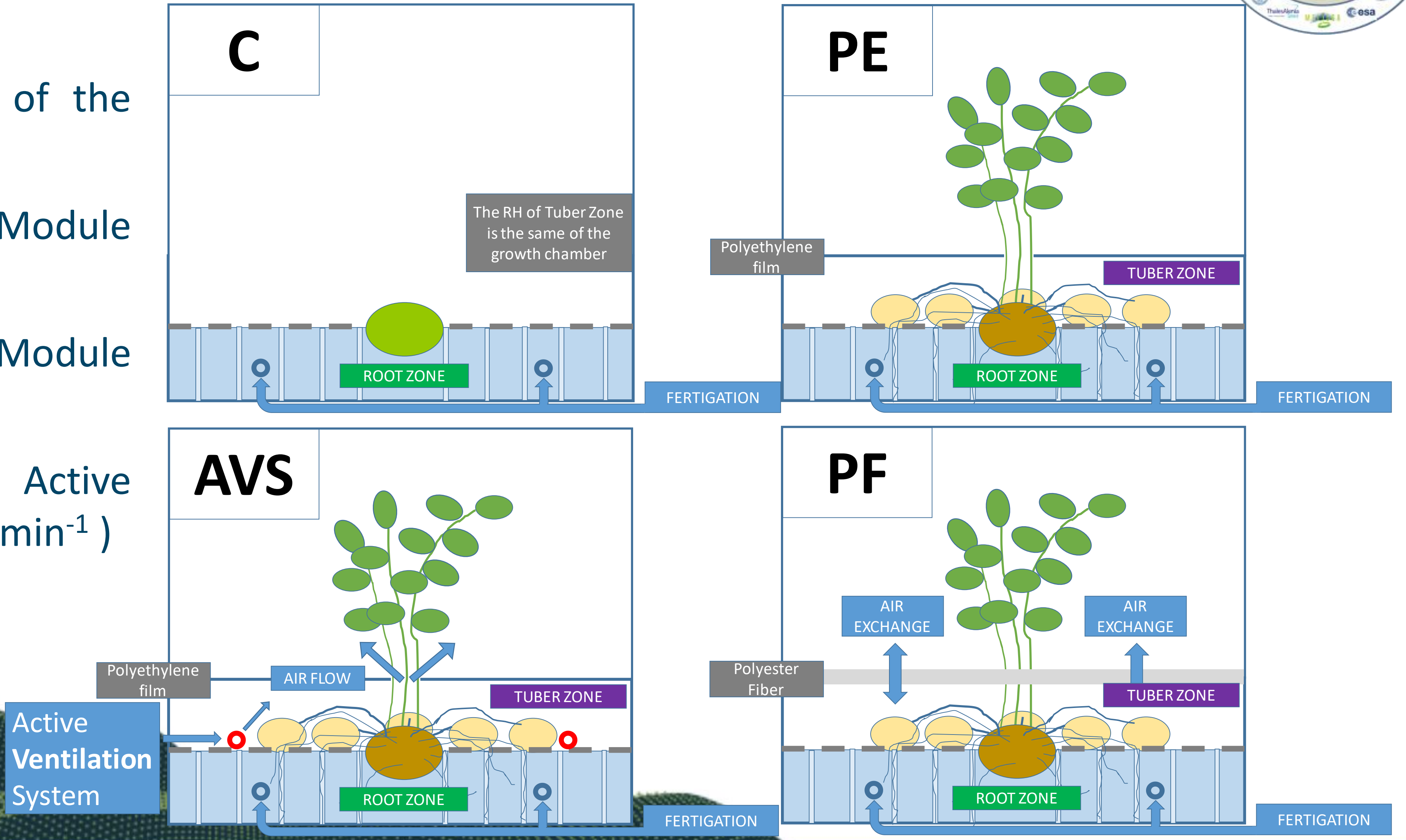
Materials and Methods

C: Control (no cover of the Root Module)

PE: Cover of the Root Module with Polyethylene Film

PF: Cover of the Root Module with Polyester Filter

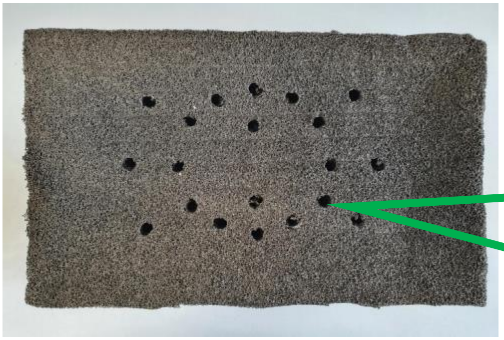
AVS: PE plus Active Ventilation System (7L min^{-1})



Materials and Methods

- Plant material: potato tuber-seeds cv. “Colomba”

- Substrate: PVA sponge



Hole pattern to improve the air diffusion in the sponge

- Two perforated tubes inserted longitudinally into the sponge to deliver water and nutrients

Materials and Methods

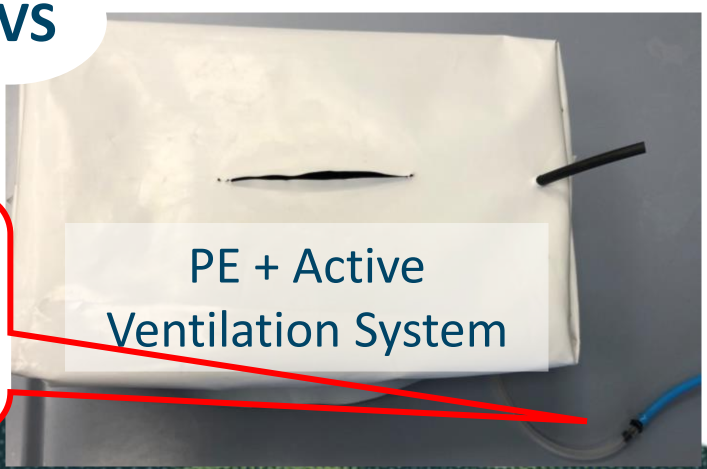
Four treatments replicated six times (24 experimental units)

C

PE

light- and gas-proof

AVS



Continuous Airflow (7L min^{-1}) in the tuber zone

PF

light-proof but gas-permeable

Materials and Methods

Blowing system for AVS

Continuous Airflow
(7 L min^{-1}) by air pumps

Perforated pipes (36 holes)

Materials and Methods

Measurements:

- Air relative humidity in the tuber zone (continuously)
- Total delivered water

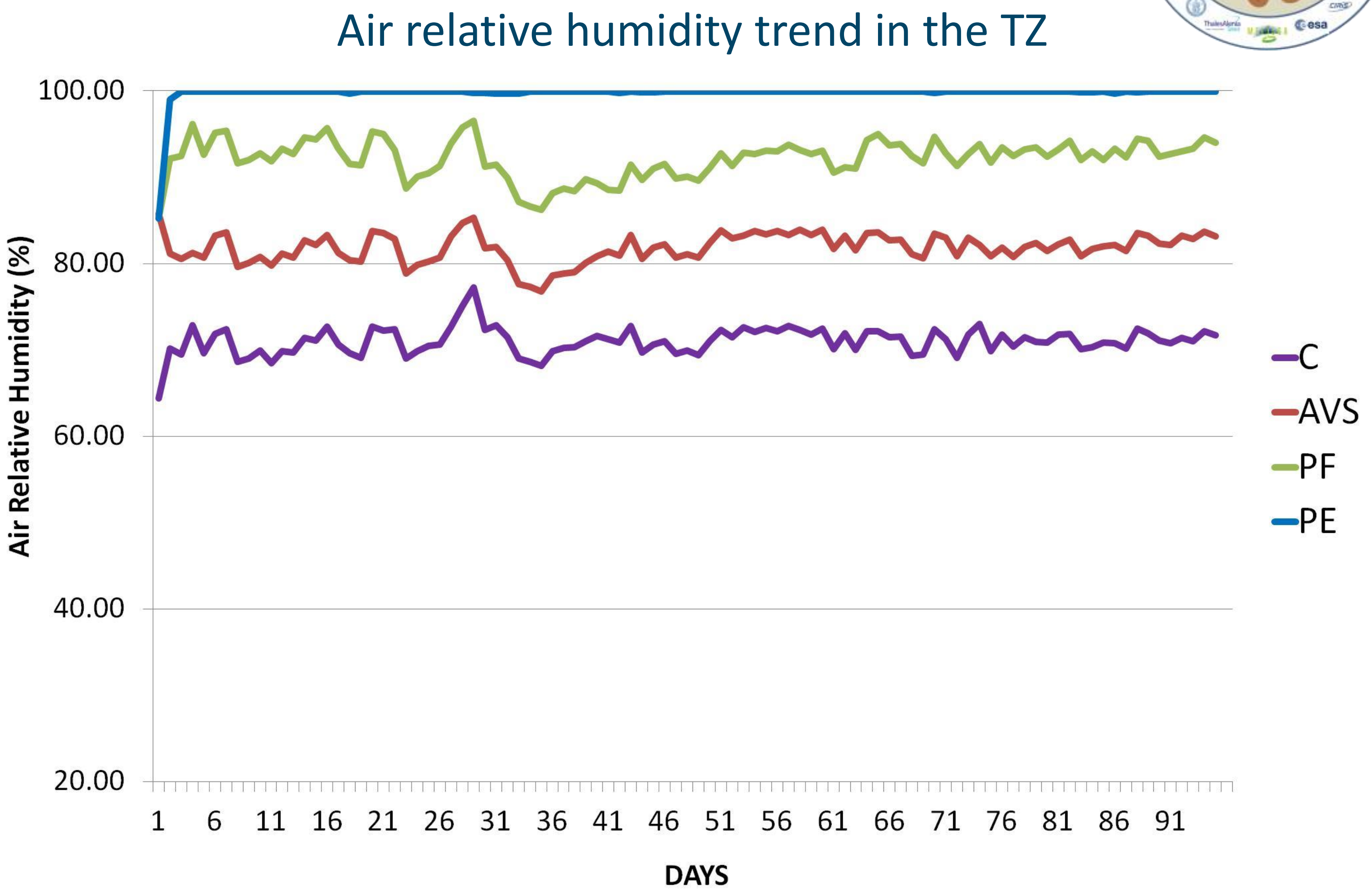
Trays were weighted at regular time intervals (every two days); lost water was replenished by plain water and/or by nutrient solution to keep the electrical conductivity in the root zone at 1.8 dS m^{-1}

Environmental conditions in the growth chamber:

Temperature 24/18°C; Relative Humidity 60%/80% (day/night regime)
Photoperiod: 16h/8h (day/night regime)
PPFD: 400-450 µmol m^{-2} s^{-1}
Nutrient solution recipe by Molders et al., 2012: Electrical Conductivity (EC) 1.8 dS m^{-1}; pH 5.9

Main Results

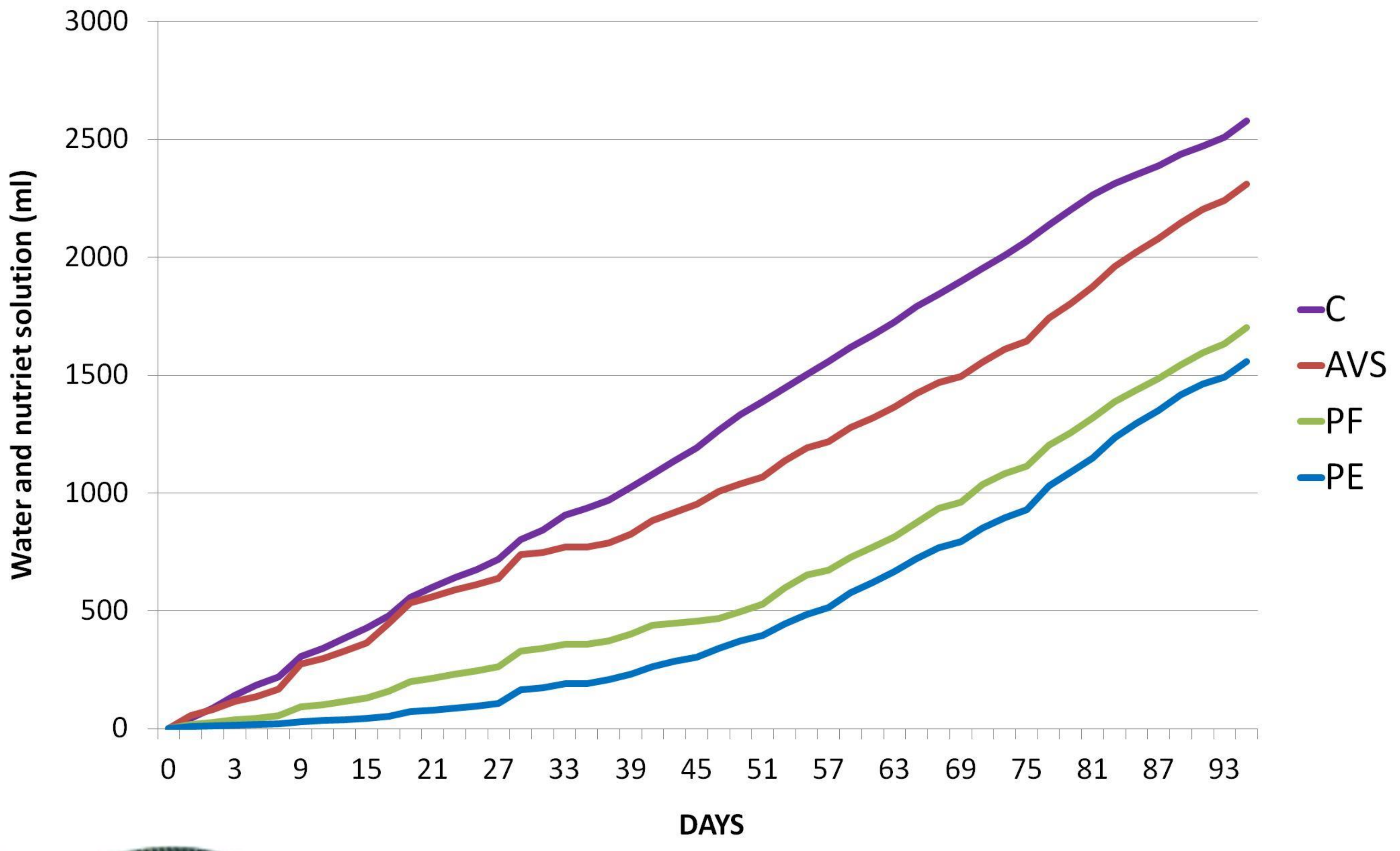
- Throughout the experiment, the air relative humidity (RH) of the TZ was kept almost constant in all treatments;
- control (C), without cover, recorded RH values of about 70%;
- PE cover implied in condensing RH levels (100%).
- PF cover provided a 10% reduction in RH compared to PE cover, while AVS established RH values around 80%.



Main Results

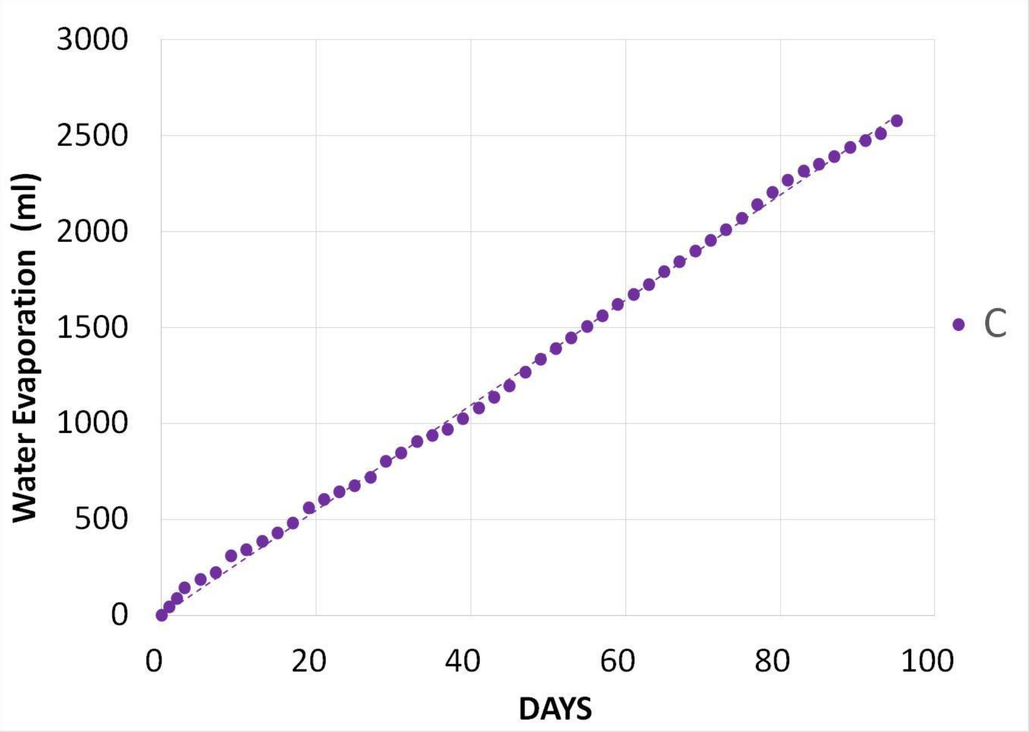
Cumulative use of Water (W) and Nutrient solution (NS)

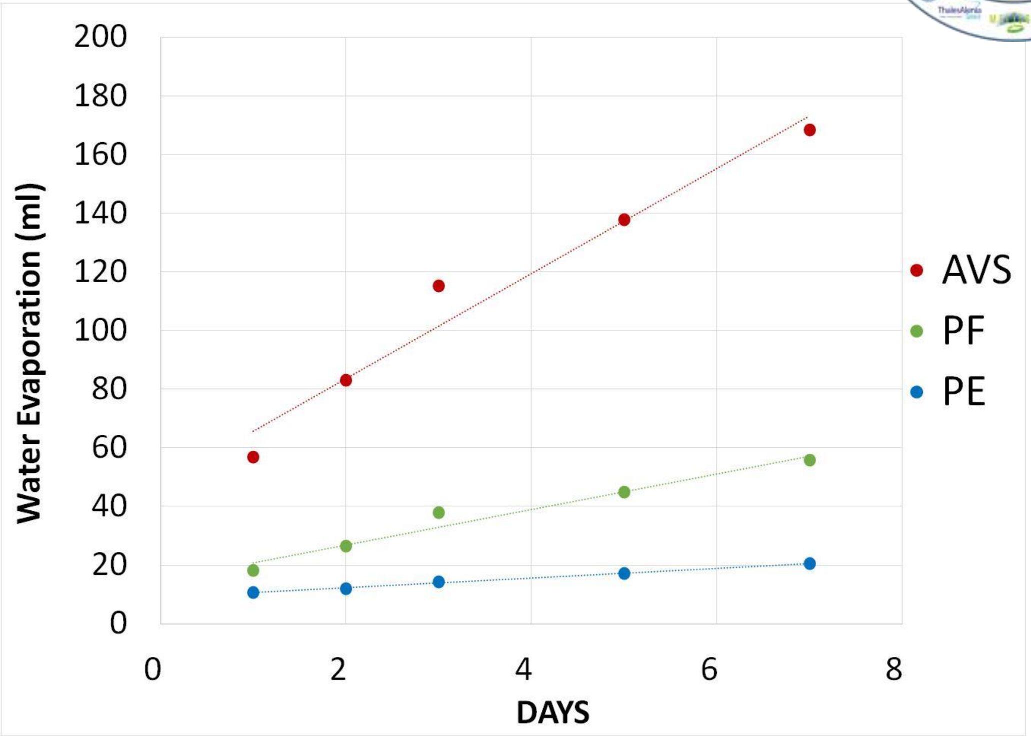
- Water use in C depended entirely on evaporation (shoots absent);
- in PE (lowest consumption observed) the increment was mainly due to transpiration;
- in PF, the higher water use compared to PE, was due to additional evaporative losses through the cover;
- in AVS, the higher W/NS consumption than in PF was due to water evaporation from the substrate driven by air flow.



Main Results

Cumulative Evaporation





Differences in water consumption among the treatments were mainly due to differences in water evaporation, which was strongly increased by the air ventilation system

Mean daily evaporation

C	27.76	ml day^{-1}
AVS	12.44	ml day^{-1}
PF	7.73	ml day^{-1}
PE	5.86	ml day^{-1}

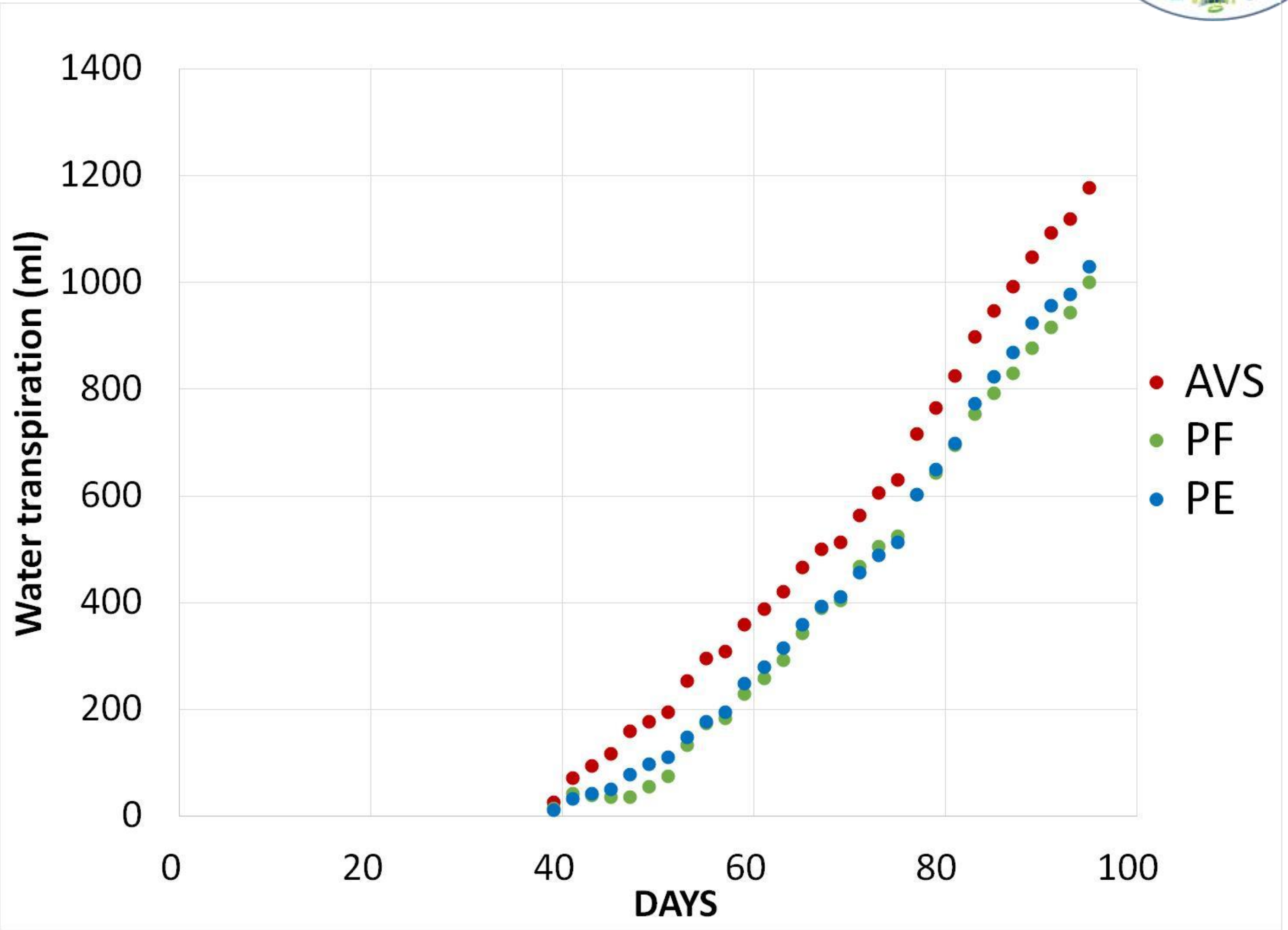
Main Results

- Crop transpiration (estimated as the difference between the amount of water used and the amount of evaporated water) was similar among the different treatments.
- The air ventilation system increased the transpiration compared to the PE, probably due to the higher shoot vigor.

Mean daily traspiration

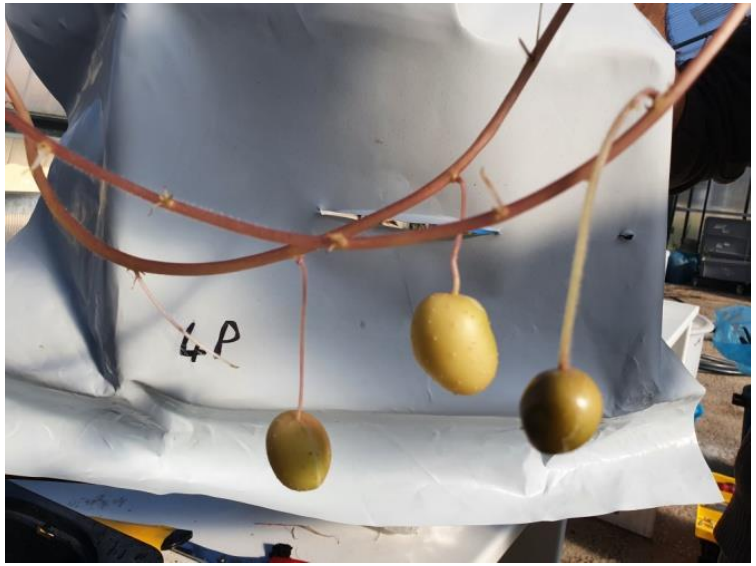
AVS	20.55	ml day^{-1}
PF	17.61	ml day^{-1}
PE	18.19	ml day^{-1}

Cumulated Transpiration



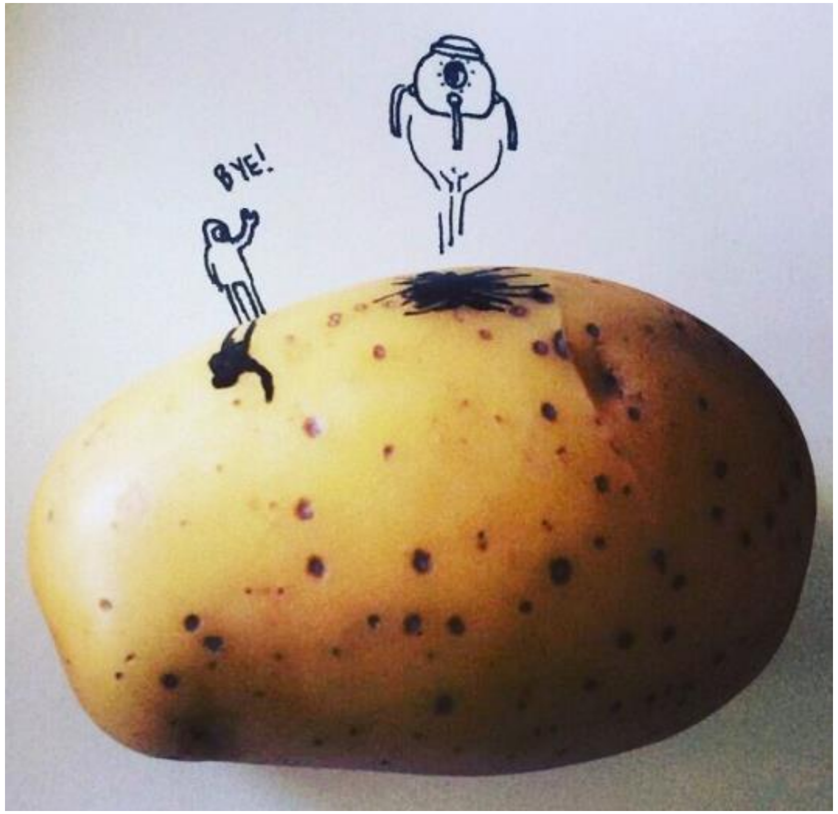
Main Results

In all the experimental treatments tubers were obtained



Take-home messages

- Covering the Root Module with Polyester Filter or Polyethylene Film reduced water use with no effect on plant transpiration;
- Polyester Filter lowered the air relative humidity in the tuber zone compared to Polyethylene Film;
- The Active Ventilation System lowered the air relative humidity in the tuber zone compared to the PE cover and increased water use (and plant growth);
- Overall, it is recommended to use the Active Ventilation System only in the early stages to avoid sprout necrosis, while it can be unnecessary after the shoot emergence from the cover.



2022 MELISSA CONFERENCE
8-9-10 NOVEMBER 2022

www.melissafoundation.org

Follow us

THANK YOU.

Luigi Giuseppe DURI
University of Naples Federico II

Luigigiuseppe.duri@unina.it

SPONSORS

ESTEE
EARTH SPACE TECHNICAL ECOSYSTEM ENTERPRISES

ThalesAlenia Space
a Thales / Leonardo company

SHERPA ENGINEERING

beyond gravity

ENGINSOFT

QINETIQ

BioX technologies

BLUE HORIZON

SPARTAN SPACE

frontiers

PARTNERS