MELiSSA
MICRO-ECOLOGICAL LIFE SUPPORT SYSTEM ALTERNATIVE

CREATING A CIRCULAR FUTURE

Design of a module for cultivation of tuberous plants in Space: the project Precursor of Food Production Unit (PFPU)

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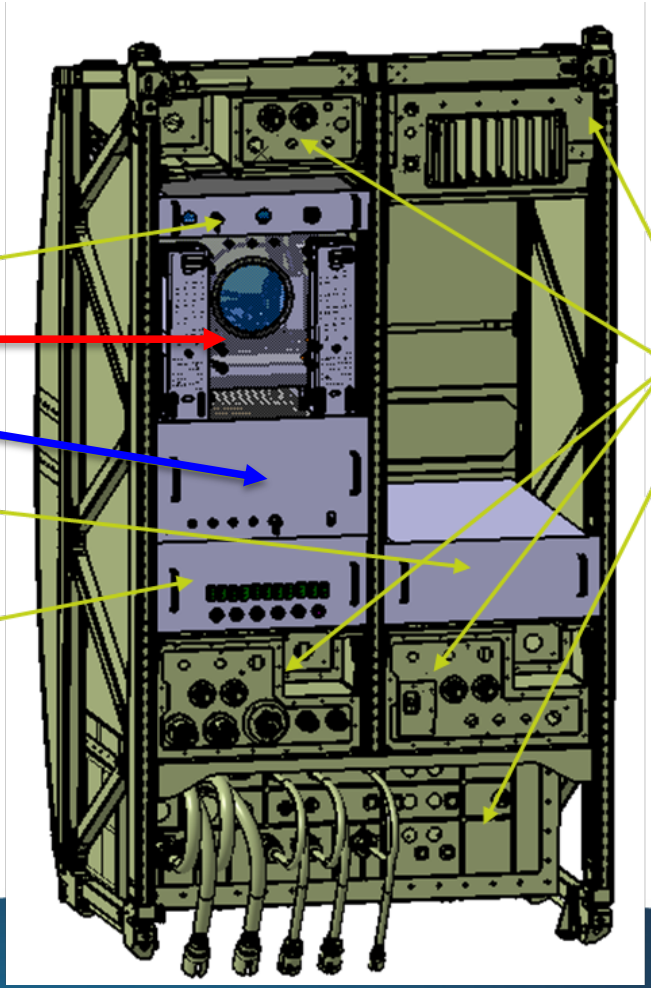
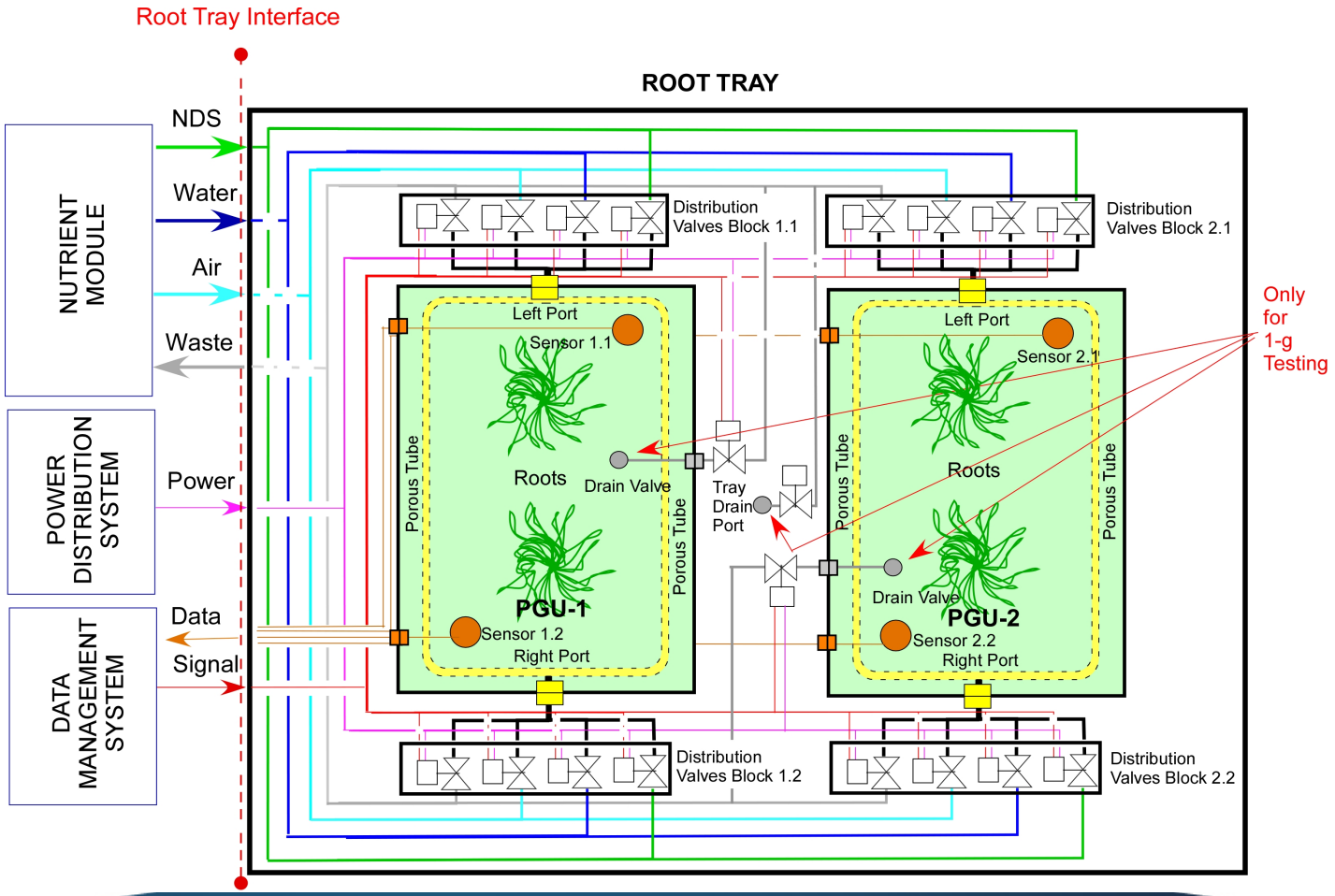
PFPU overview



Root module (RM) and plant growth unit (PGU) layout



PFPU1 - Objectives

Test 1

Substrates hydrological characterization: to investigate the hydrological behaviour of different synthetic and organic materials

Test 2

Sensors calibration and water distribution system set-up: to calibrate moisture sensors and to test the designed porous tubes system in the selected substrate

Test 3

Tuber seeds germination and plant growth: to identify the best substrate for the early phases of development, and to verify the plant ability to complete a tuber-to-tuber cycle in the proposed layout

Materials and Methods

1. Substrate selection and characterization (Laboratory)

- 3 synthetic materials, Oasis Horticubes® (phenolic foam), rockwool and capillary mat (polyester fiber) and 3 organic materials, cellulosic sponge (100% cellulose), cotton wool and hemp plus kenaf fibers
- Saturated hydraulic conductivity (K_s) and the Water retention curves

2. Sensor selection and calibration (Laboratory)

- Calibration of WaterScout SM 100 Soil Moisture Sensor on cellulosic sponge
- Water distribution test in the substrate/porous tubes integrated system

3. Plant cultivation in controlled environment (Growth chamber)

- Selection on 2 candidate cultivars, 'Avanti' (Stet Holland B.V.) and 'Colomba' (HZPC Holland B.V.)
- Germination test of certified potato tuber seeds and plant growth trial in growth chamber in the PGU prototype

Test 1 - Substrates hydrological characterization

Substrate selection

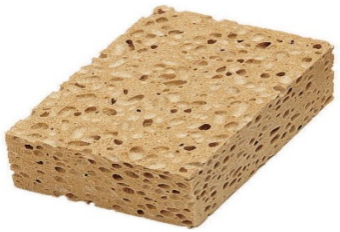

Oasis


rockwool


capillary mat

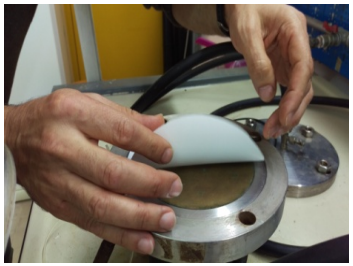

cotton


canapa + kenaf


cellulosic sponge

Saturated hydraulic conductivity (K_s)

Water retention curves



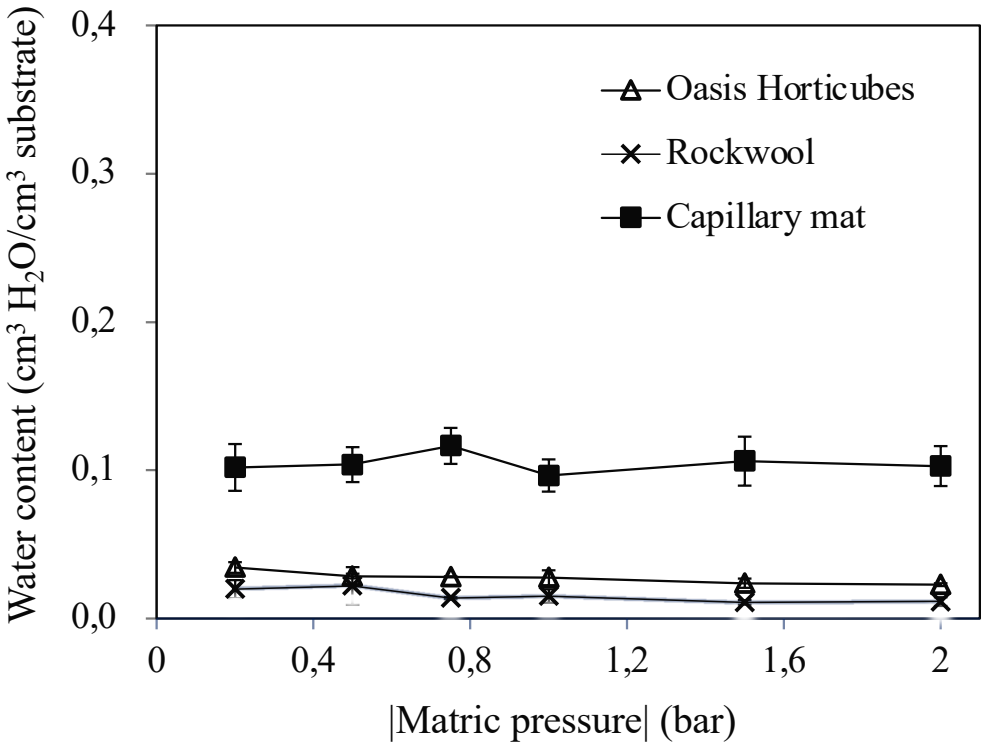
Physical and hydrological properties

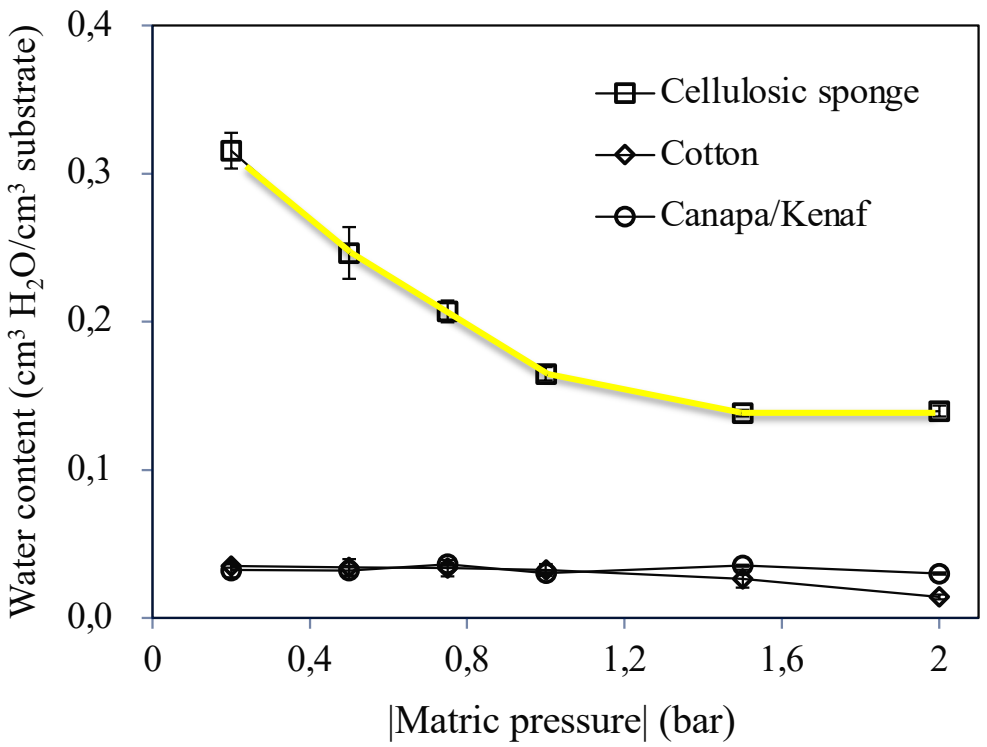
(Mean ± St. error; n=3)

	Saturated hydraulic conductivity (K_s, cm/s)	Bulk density (ρ, g/cm^3)	Container capacity (CC, cm^3/cm^3)	Water retention	Structural evaluation	Final evaluation
Oasis Horticubes	2.82±0.09	0.021±0.001	0.56±0.01	Intermediate	Fragile and inconsistent (dispersion of dust)	Good hydraulic properties, bad handling
Rockwool	0.70±0.03	0.059±0.001	0.94±0.02	Low	Incoherent (dispersion of dust)	Poor water retention, bad handling
Capillary mat	0.27±0.02	0.145±0.010	0.90±0.03	Low	Compact with low thickness	Poor water retention, good handling
Cellulosic sponge	0.30±0.01	0.124±0.003	0.94±0.02	Good	Elastic and resistant	Very good hydraulic properties, good handling
Cotton wool	0.31±0.01	0.021±0.001	0.33±0.02	Intermediate	Easily adaptable and compressible	Good hydraulic properties, medium handling, suitable for mulching
Canapa/Kenaf	0.88±0.02	0.049±0.001	0.72±0.03	Low	Extremely rigid and compact	Poor water retention, bad handling

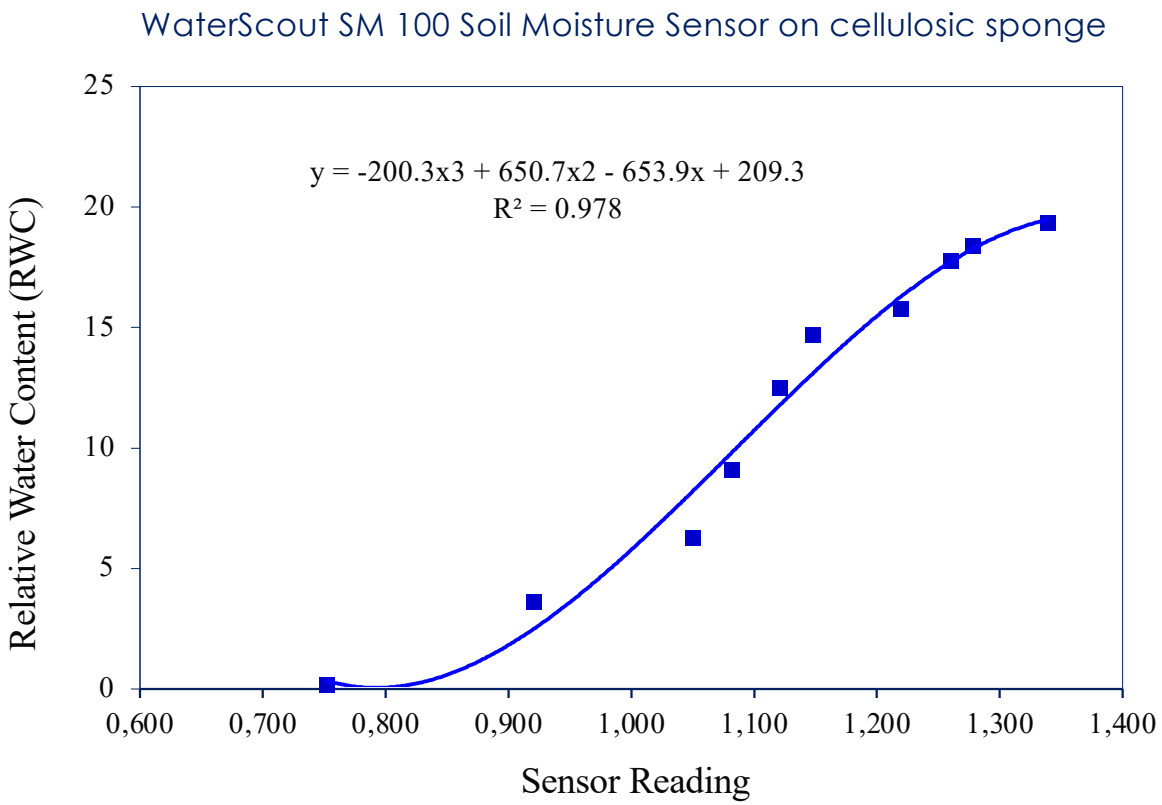
Water retention curves

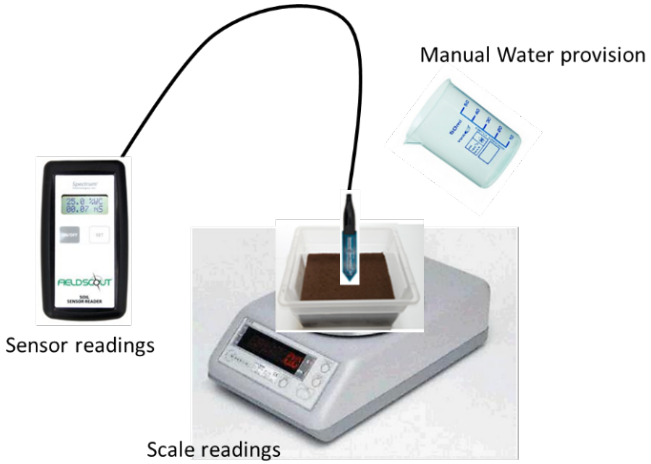
(Mean ± St. error; n=6)

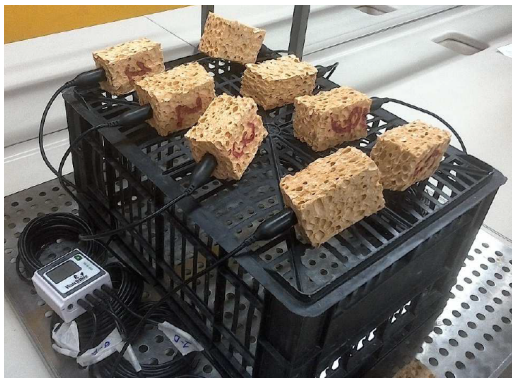


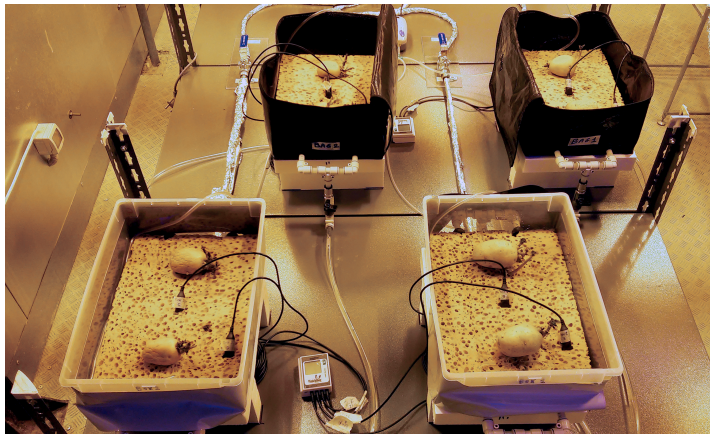


Test 2 – Water sensors calibration

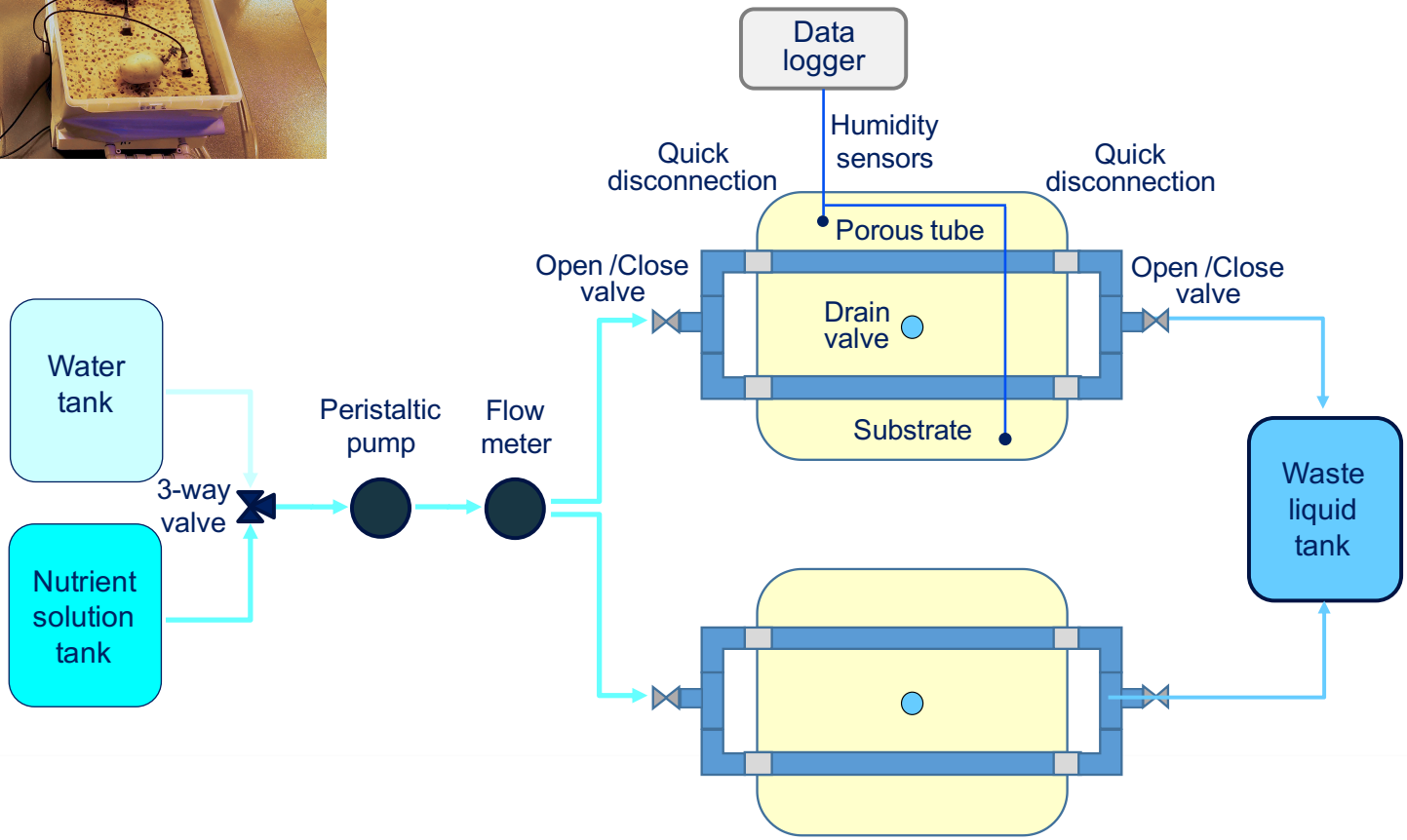








Test 2 – Water distribution system set-up

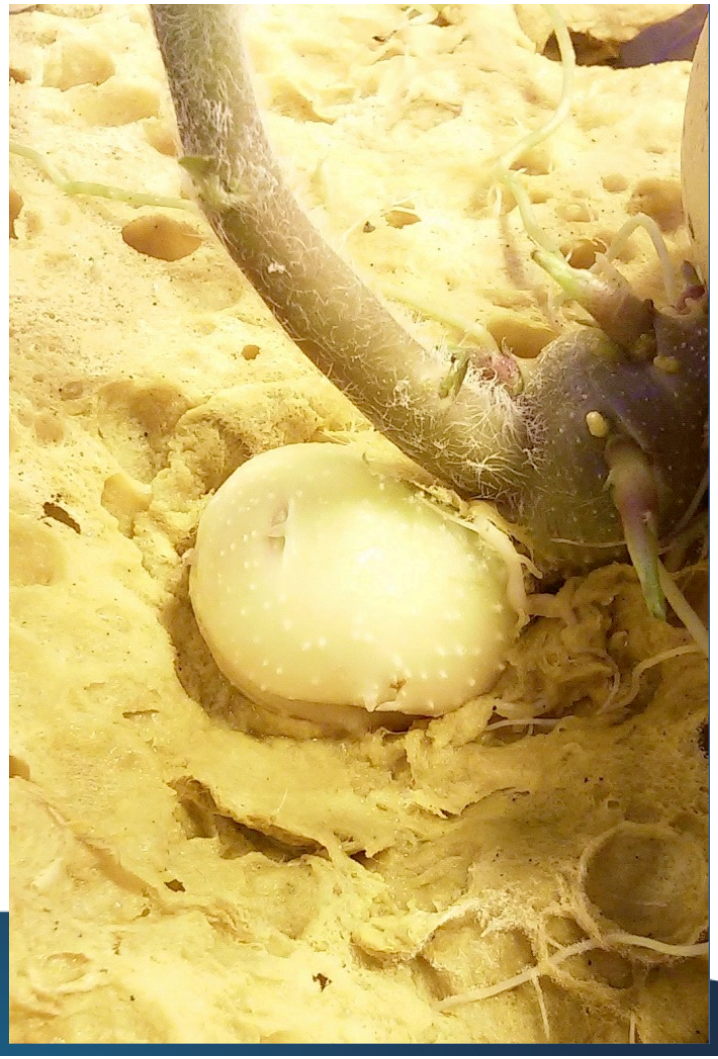


Test 3 - Tuber seeds germination

(Mean ± St. error; n=6)

	'Avanti'		'Colomba'	
	Sprouting (%)	ATS (days)	Sprouting rate (%)	ATS (days)
Oasis Horticubes	100	29.5±2.3	100	16.2±2.2
Capillary Mat	100	32.0±2.9	100	12.7±0.5
Cellulosic sponge	83	41.2±8.3	100	15.7±1.6

Test 3 - Plant growth



Preliminary conclusion

The proposed design of the RM, including cellulosic sponge and a porous tube based system for water distribution, was efficient in guaranteeing the proper conditions to obtain healthy plants, able to complete the tuber-to-tuber cycle.

PFPU2

Experimental design

2 potato cultivars

- Colomba

- Primura

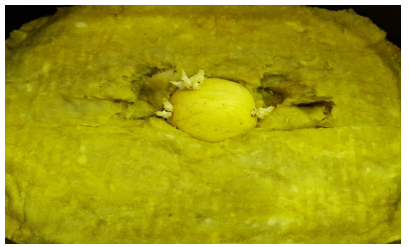
X

3 substrates

- Cellulose sponge

- PVA sponge

- Rockwool



PFPU2

Tuber-seeds rooting

Colomba

Substrate	Tuber-seeds with roots (%)				
	5 DAT	10 DAT	15 DAT	20 DAT	25 DAT
Cellulose	16.7	50.0	66.7	66.7	100.0
PVA	33.3	66.7	66.7	83.3	100.0
Rockwool	33.3	83.3	100.0	100.0	100.0

Primura

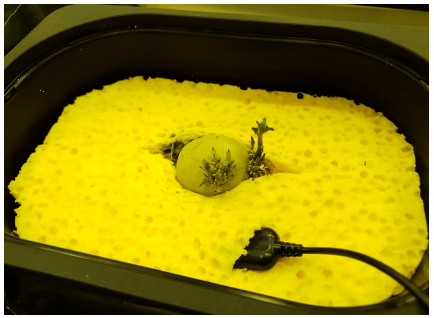
Substrate	Tuber-seeds with roots (%)				
	5 DAT	10 DAT	15 DAT	20 DAT	25 DAT
Cellulose	0.0	16.7	50.0	66.7	100.0
PVA	0.0	33.3	50.0	66.7	100.0
Rockwool	0.0	50.0	100.0	100.0	100.0

PFPU2

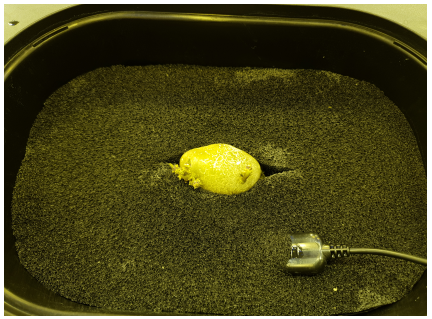
Plant development

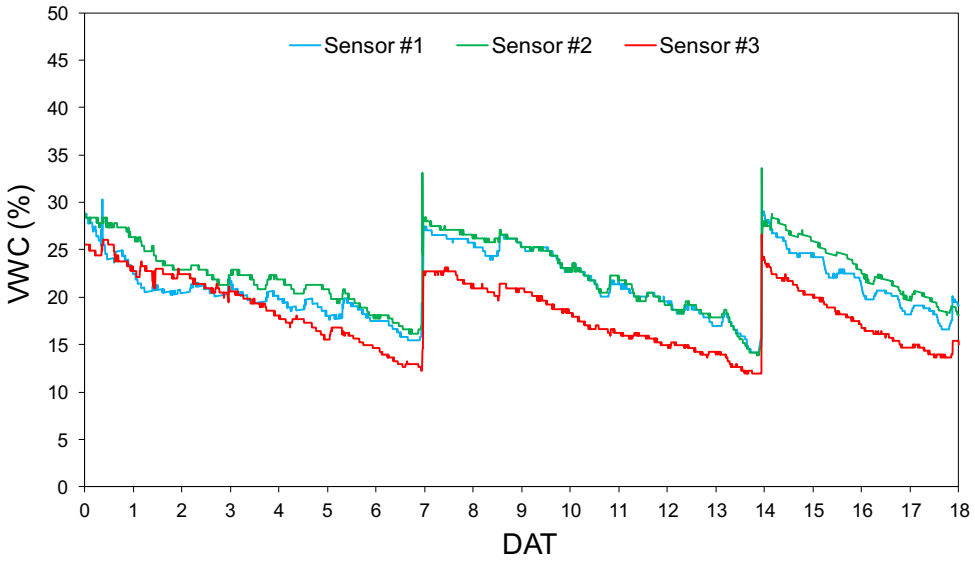
PFPU2 - Sensor performance: Volumetric Water Content (VWC)

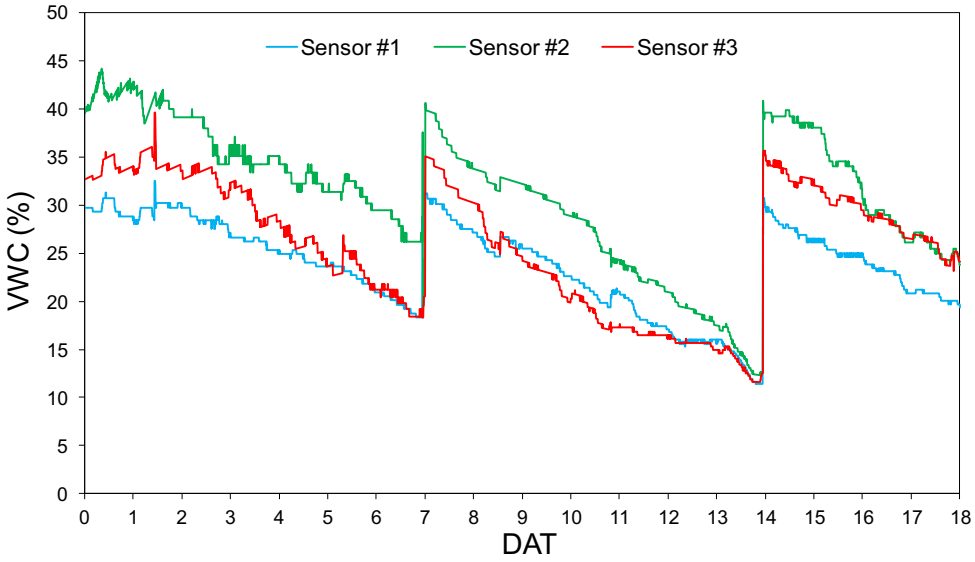
Cellulosic sponge



PVA sponge

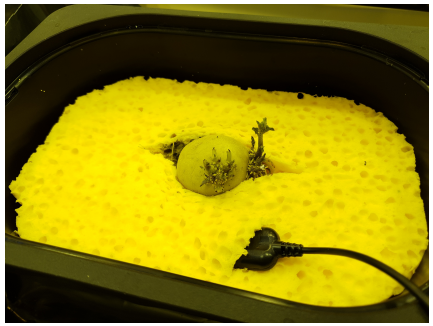




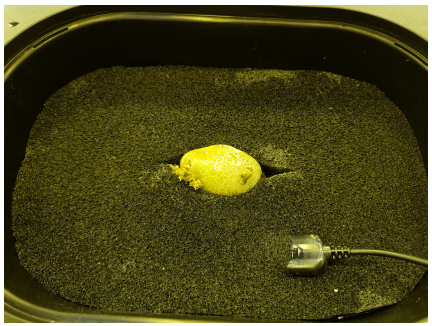


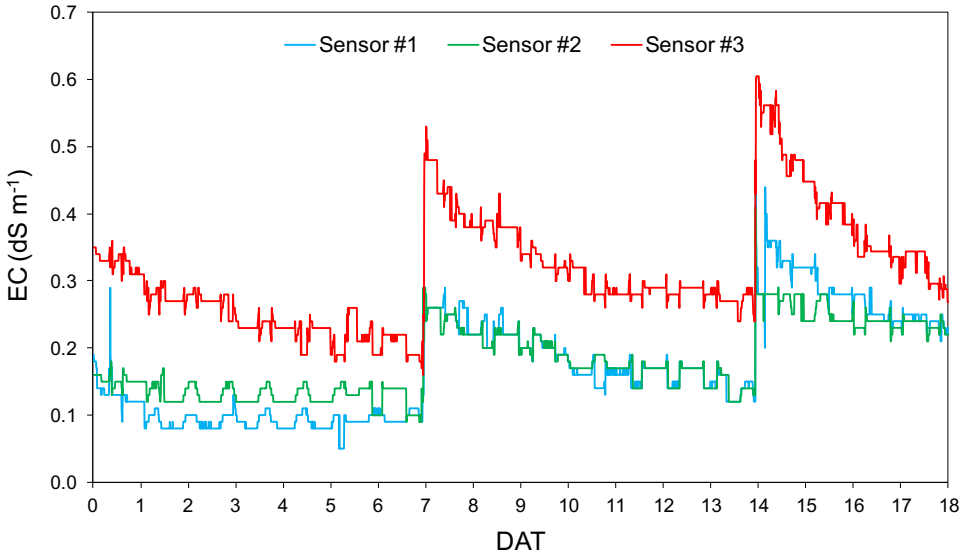
PFPU2 - Sensor performance: Electrical Conductivity(EC)

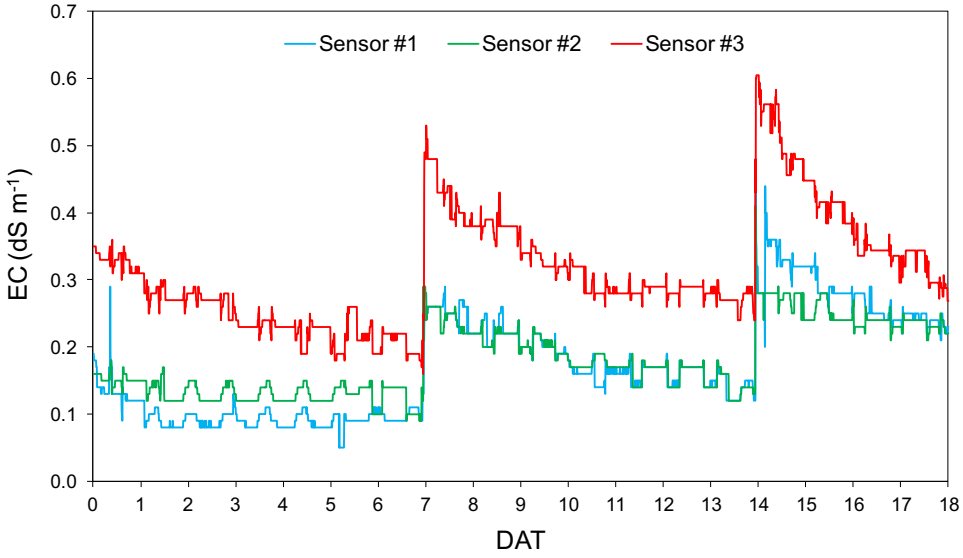
Cellulosic sponge



PVA sponge

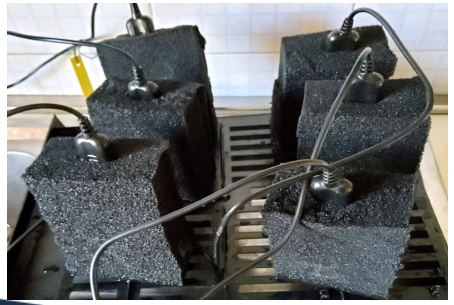






Conclusion

- Cultivar ‘Colomba’ was earlier than ‘Primura’ in terms of both rooting and shoot emission.
- PVA sponge performed better than cellulosic sponge by determining a earlier development of tuber-seeds and it was immune to pathogens.
- The WaterScout SMEC 300 sensors can be used effectively to monitor VWC and EC of spongy substrates with an accurate calibration of the sensor/substrate combination.



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Funding
ESA - MELiSSA project "Precursor of Food Production Unit – Phase A System Study" (PFPU), ESA contract No. 4000114057/14/NL/AT

Details in

- **Paradiso et al. 2019**. Growth, photosynthetic activity and tuber quality of two potato cultivars in controlled environment as affected by light source. Plant Biosystems, 153(5): 725-735
- **Paradiso et al., 2020.** Design of a module for cultivation of tuberous plants in microgravity: the ESA project "Precursor of Food Production Unit". Frontiers in plant science, 11: 417.

THANK YOU.

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