DEVELOPMENT OF INNOVATIVE PROCESSES FOR THE INDUSTRIAL CULTIVATION OF HIGH ADDED-VALUE PLANTS IN A VERTICAL FARMING PILOT SYSTEM

NICO BETTERLE
University of Verona (Italy)

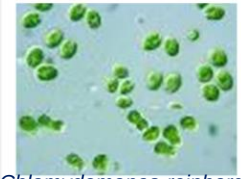
EXPONENTIAL FARMING®

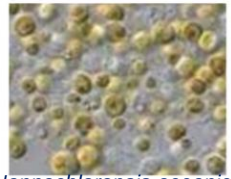
What do we do?

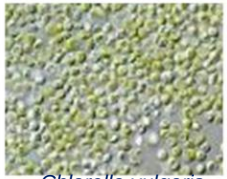
prof. Matteo Ballottari
(reach out to him at Melissa conference)

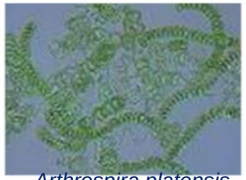
SOLE Lab
Solar Energy Bio-exploitation Lab

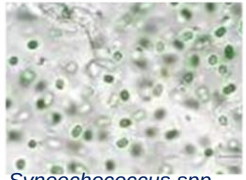
Microalgae


Chlamydomonas reinhardtii


Nannochloropsis oceanica


Chlorella vulgaris


Arthrospira platensis


Syneechococcus spp.

Higher plants


Microgreens

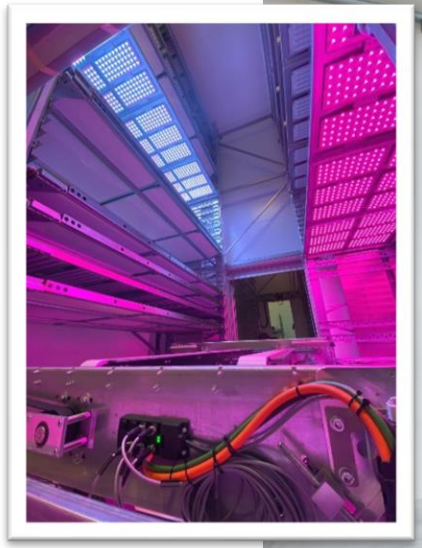

Basil


Lettuce


Tobacco

Who is our partner?

ONOEX Farm-0 currently working in Verona (Italy)



https://onoexponentialfarming.com/

Combination of:

- ***mechatronic,***
- ***agriculture***
- ***biotechnology***

First in North-East Italy!

Collaborating since 2018

Plants for food or CO2 capture

Start | End | Easy regeneration (14 days)

447plants/mq

247plants/mq

147plants/mq

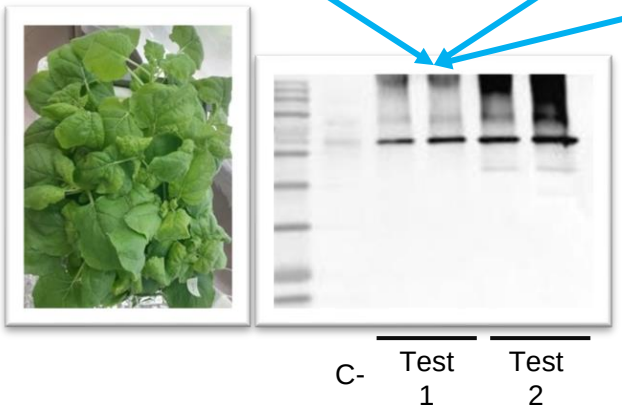
Basil

Tobacco

Fast growth and regeneration of hydroponically grown plants

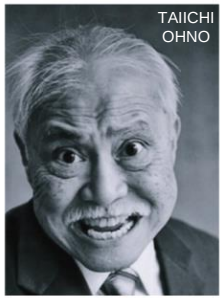
Increase of environmental [CO2] allowed to achieve higher biomass yield
(lettuce >100kg/m²/Y; basil >100kg/m²/Y; tobacco >200kg/m²/Y)

Plants for pharma



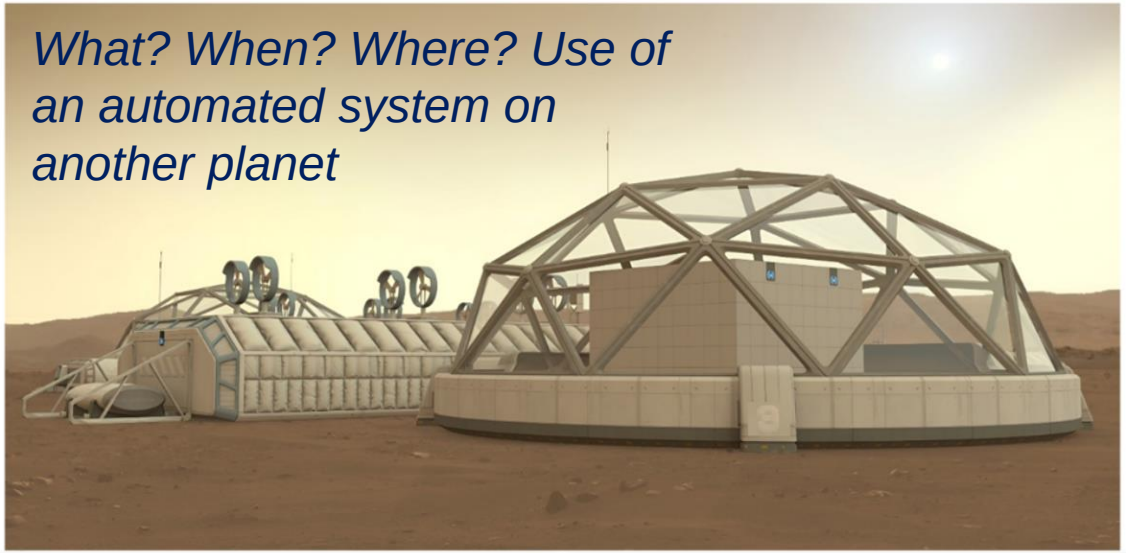
Spraying of viral vectors to produce pharmaproteins from hydroponic plants

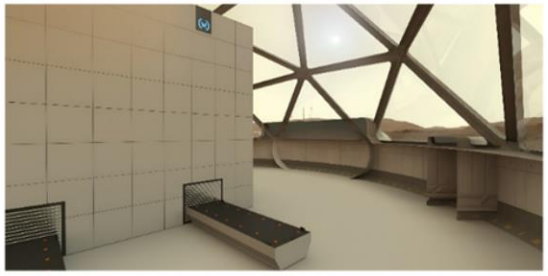
5Ws for Lean Farming



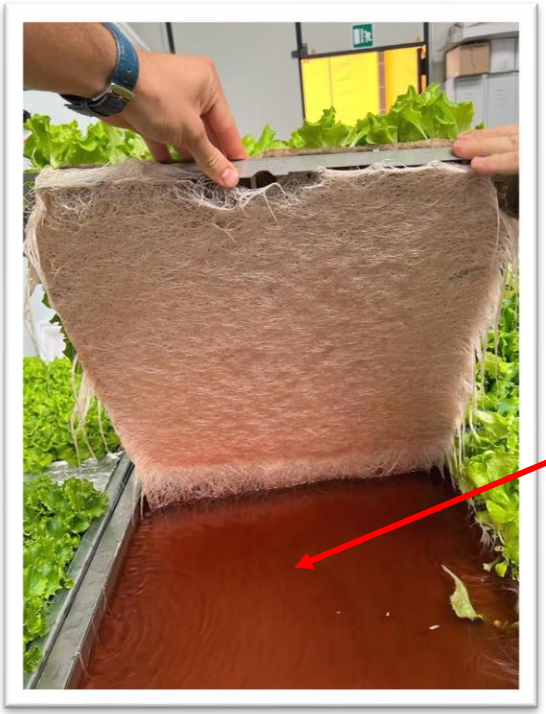
5 W'S PRINCIPLE:

- WHAT IS NEEDED,
- WHEN IS NEEDED,
- WHERE IS NEEDED,
- WITHOUT WASTE



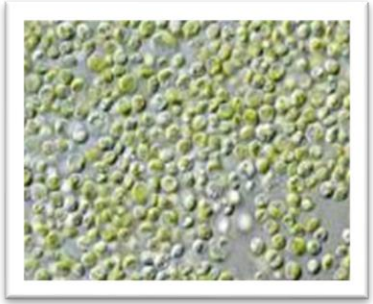


Without Waste? Valorization by microalgae

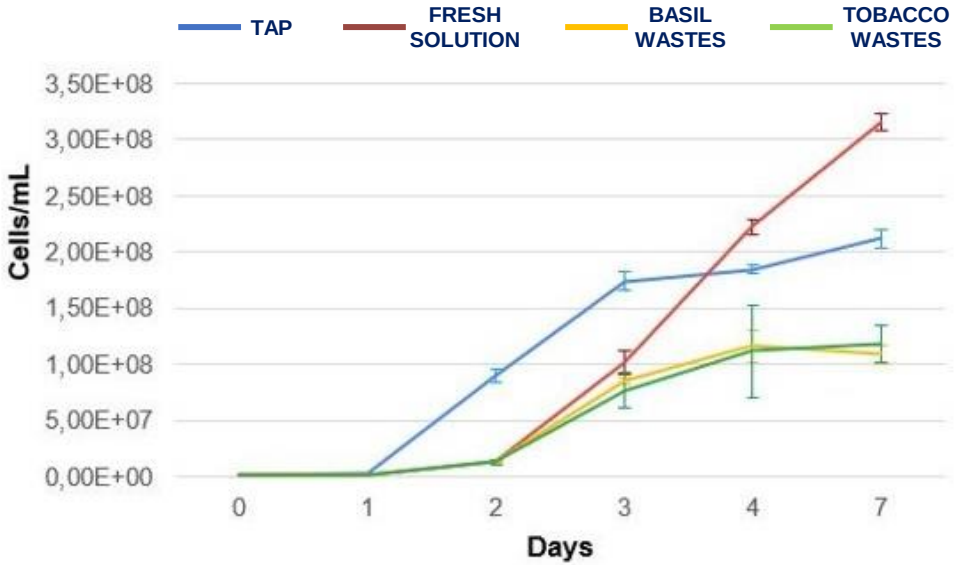


Hydroponic solution at the end of a growth cycle ***still contains nutrient salts***

Microalgae can consume residual salts producing useful biomass (superfood, plant biostimulant)



Proof of concept: growth of Chlorella in hydroponic wastes



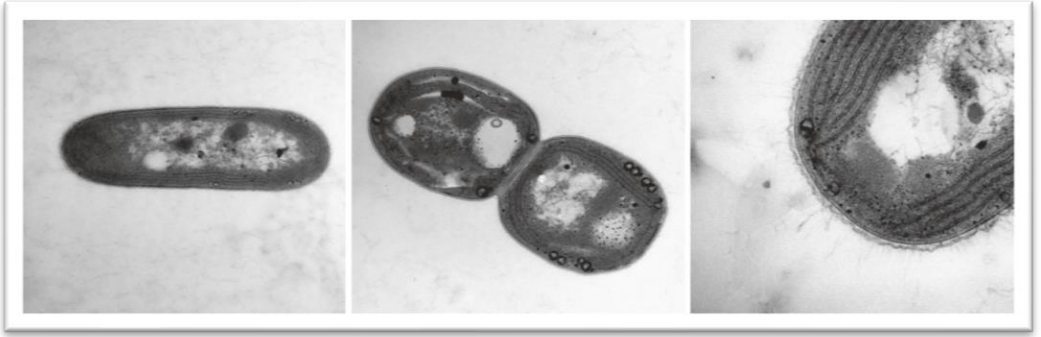
Microalgae grown in used hydroponic media reached stationary phase earlier than cells cultivated in fresh nutrient solution

Consumption of residual nutrients by microalgae

	PO_4^{3-} (mg/L)			NO_3^- (mg/L)		
	Before algae	*After algae*	*Reduction (%)*	*Before algae*	*After algae*	*Reduction (%)*
Fresh solution	130	25	**81%**	1098	80	**93%**
Basil wastes	92	18	**80%**	1186	350	**70%**
Tobacco wastes	130	9	**93%**	1018	306	**70%**

Most part of the residual nutrients were consumed in just 7 days

Synechococcus PCC 11901: a promising strain for wastes valorization



COMMUNICATIONS BIOLOGY

May 2020

ARTICLE

https://doi.org/10.1038/s42003-020-0910-8 OPEN

Newly discovered *Synechococcus* sp. PCC 11901 is a robust cyanobacterial strain for high biomass production

Artur Włodarczyk[1,3✉], Tiago Toscano Selão[1,4], Birgitta Norling[1] & Peter J. Nixon[1,2✉]

- *Biosafety level 1 organism*
- *short doubling time of ≈2 1/2 hours*
- *grows at high light and in a wide range of salinities*
- *accumulates up to ≈33 g(dcw)/L*
- *naturally transformable*

Robust and quick growth


Day 0


Day 1


Day 3


Day 5


Day 7

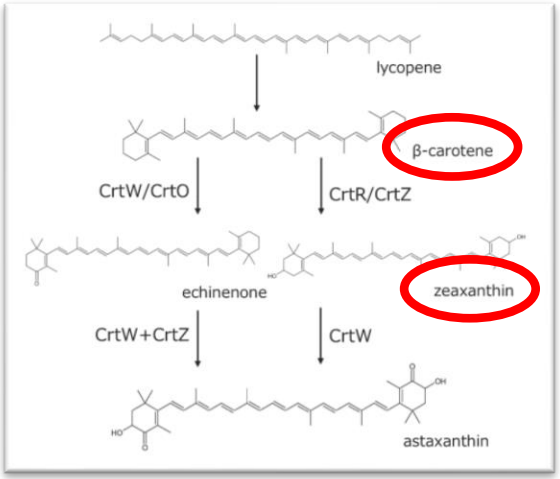
Tested lights	***1200 µE (left)*** ***1600 µE (center)*** ***2000 µE (right)***
Temperature	***35°C***
Bubbling	***3% CO_2***

😮

1 ml of microalgal ***PHOTOAUTOTROPHIC*** *colture*

More than 15g/L in a week!

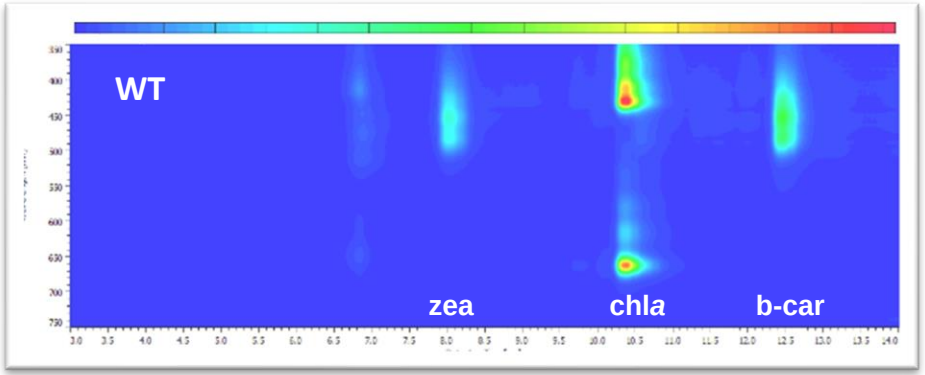
Synthesis of high-value compounds

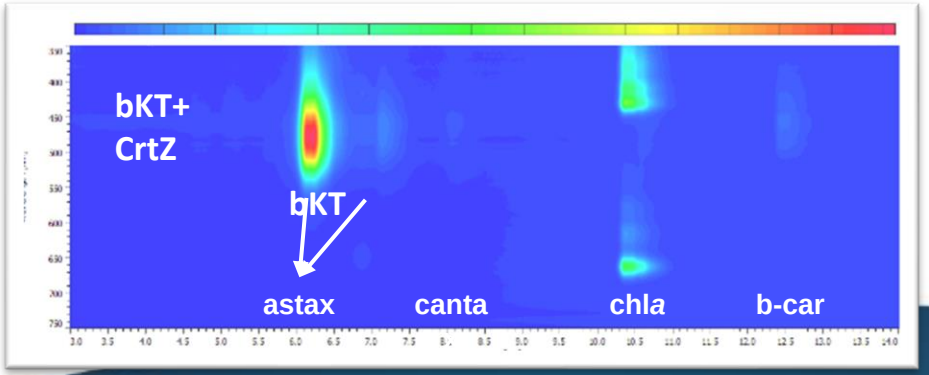


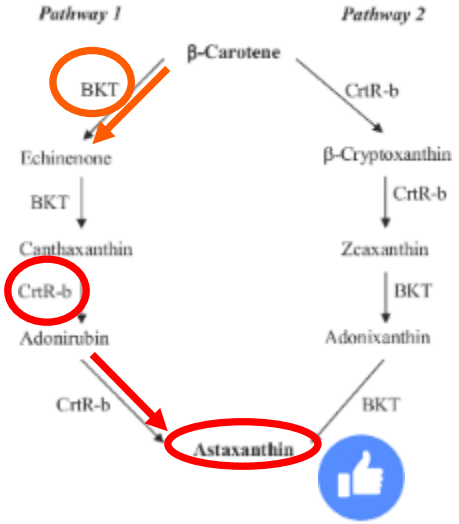
Cyanobacteria naturally accumulate Zeaxanthin and b-carotene

HIGH POTENTIAL AS PLATFORMS FOR ASTAXANTHIN SYNTHESIS

Engineering of Synechococcus

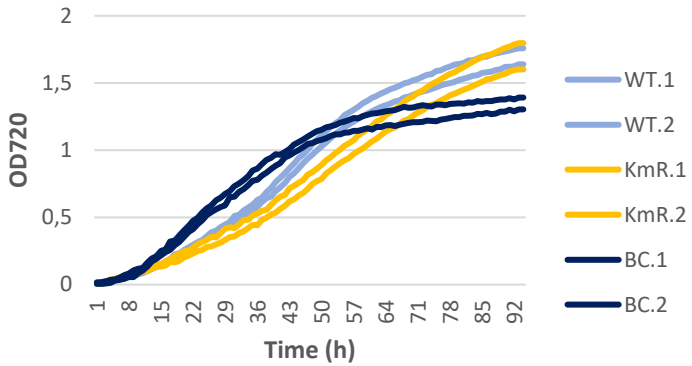




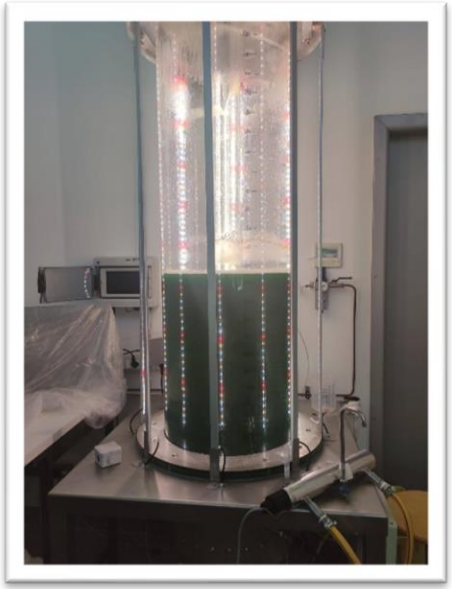


Accumulation of Astaxanthin
~0.5% g/g dcw

Growth in photobioreactor



Astaxanthin makes cells growing faster (PATENT PENDING)



Engineered strain has been successfully cultivated in 200L non-sterile media

Conclusions

- *Availability of an automated indoor-system to produce 1) what is needed and 2) where is needed*

- *Potential of microalgae to achieve an hydroponic cultivation without waste*

- *Full exploitation of new highly-performing microalgal strain*

Acknowledgements

Department of Biotechnology, University of Verona

https://onoexponentialfarming.com/

Santa Maria di Zevio, Verona, Italy

Prof. Matteo Ballottari
Kristina Ljumovic
Anna Baietta

Thomas Ambrosi
Simone Zecchinato
Lorenzo Girelli
Matteo Castioni

Cariverona (funding)