Proposed List of MELiSSA PhD Topics

Topic Title: Response of higher plants to nitrogen sources from processed human urine

Keywords: nitrogen species**,** crop species, MELiSSA loop

Abstract

MELiSSA stands for "Micro-Ecological Life Support System Alternative". MELiSSA is the European project for circular life support systems and is characterized by a biological and chemical/physical approach based on first principles modelling and implementation of a suitable deterministic engineering approach. Within the MELiSSA loop, the production of oxygen from carbon dioxide, the processing of water and the production of edible biomass is performed by the higher plant compartment, designed to accommodate various crop species (*Lactuca sativa, Solanum tuberosum, Triticum aestivum, Triticum durum, Glycine max, Oryza sativa, Solanum lycopersicum, Allium cepa, Spinacia oleracea*).

Based on circularity principles, the integration of this higher plant compartment within a space mission implies the use of processed human urine as a supply of nitrogen element required for the crop growth. Previous studies investigated the effect of various ratio of NH_4^+ and NO_3^-, the effect of higher Na^+ level in the hydroponic solution. These studies informed of the resultant effect of the studied ratios in terms of plant biometric characteristics, such as for instance leaf area, root and shoot quantities, and in terms of engineering information, such as for instance yield requirement of upstream process (i.e. urine processing). Although consistent with previous observations reported in the literature, the details underlying these observations need to be explored in terms of acute stress and chronic stress. As a matter of fact, previous observations are based on applying the treatment during the full crop life cycle. The temporary application of the treatment would need to be investigated to inform of the possible performance recovery of the crop and relative time required for it.

The proposed PhD shall study the acute and chronic stress relative to the use of processed human urine as a fertiliser. Attention will be given to understanding of the stress response at metabolic, cellular, tissue and organ levels. Focus should be placed on the species *Lactuca sativa* and *Spinacia oleracea*, used in previous crop production trials and/or parabolic flights.

Impact on MELiSSA Project:

Understanding the effect of the nitrogen specie on the carbon-nitrogen metabolic coupling in higher plant will improve the current knowledge of MELiSSA loop closure

Potential MELiSSA Partners:

Universitat Autonoma de Barcelona (S), University Federico II of Naples (I), CiRiS: Centre for Interdisciplinary Research in Space (NO),
Student hosted by Wroclaw University of Science and Technology (P)

References:

Chen Dong, Zhengpei Chu, Minjuan Wang, Youcai Qin, Zhihao Yi, Hong Liu, Yuming Fu. Influence of nitrogen source and concentrations on wheat growth and production inside "Lunar Palace-1" (2018). Acta Astronautica, vol 144, pp. 371-379.

Paradiso, R., Buonomo, R., Dixon, M.A., Barbieri, G., De Pascale, S. Soybean cultivation for Bioregenerative Life Support Systems (BLSSs): The effect of hydroponic system and nitrogen source (2015) *Advances in Space Research*, 53 (3), pp. 574-584.

Mona Schifloe, Oyvind Mejdell Jakobsen, Antonio Pannico, Claudia Quadri, Ann-Iren Kittang. From urine to food and oxygen: effects of high and low NH4+:NO3- ratio on lettuce cultivated in gas-tight hydroponic facility (2023), *Front. Plant Sci.,* vol 14, July 2023.

ALISSE criteria presentation. Version 1, issue 0, 18th November 2009.

ESA Technical Note 137.4 Appendix. Applicable document for using Oscar Methodology System Engineering applied to the MELiSSA data management system: requirements

Candidate's background requirements:
Candidates preferably possess a degree in plant biology, molecular biology or biotechnology. They must be familiar with microscopy techniques. It would be an advantage, if the candidates also have some laboratory experience.