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Author: Mr. Paolo Marzioli
Sapienza University of Rome, Italy, paolomarzioli@gmail.com

Mr. Giulio Metelli
ENEA - Italian National Agency for New Technologies, Energy and Sustainable Economic Development, Italy, metelligiulio@gmail.com
Dr. Luca Gugliermetti
Sapienza University of Rome, Italy, luca.gugliermetti@uniroma1.it
Dr. Luca Nardi
ENEA - Italian National Agency for New Technologies, Energy and Sustainable Economic Development, Italy, luca.nardi@enea.it
Dr. Silvia Massa
ENEA - Italian National Agency for New Technologies, Energy and Sustainable Economic Development, Italy, silvia.massa@enea.it
Mrs. Elisabetta Bennici
ENEA - Italian National Agency for New Technologies, Energy and Sustainable Economic Development, Italy, elisabetta.bennici@enea.it
Dr. Eugenio Benvenuto
ENEA - Italian National Agency for New Technologies, Energy and Sustainable Economic Development, Italy, eugenio.benvenuto@enea.it
Dr. Giuseppe Zummo
ENEA - Italian National Agency for New Technologies, Energy and Sustainable Economic Development, Italy, giuseppe.zummo@enea.it
Prof. Fabio Santoni
Sapienza University of Rome, Italy, fabio.santoni@uniroma1.it
Prof. Fabio Nardecchia
Sapienza University of Rome, Italy, fabio.nardecchia@uniroma1.it

A LOW EARTH ORBIT CUBESAT FOR TOMATO IDEOTYPE CULTIVATION

Abstract

The autonomous production of nutrients and oxygen in space is a challenge for future human space exploration. In these mission scenarios, a significant cost- and mass-saving feature is represented by recycling resources and plants could easily take charge of this process. By photosynthesis, plants can absorb carbon dioxide and consume crew waste to generate oxygen, fresh nutrients and clean water. However, no plants were adapted to space environment and no specific ideotype exists able to grow ordinarily in space. Stresses induced by microgravity, magnetic fields, radiations, artificial illumination and altered atmosphere can affect plants performances. Moreover, an ideal plant for space missions must also produce useful compounds other than common nutrients. MicroTom is a tomato variety that could be a good starting point to develop an ideotype, for future space missions, exploiting the following characteristics: small size (0.0156 m3), short life cycle (70-90 days), growth under fluorescent light, high photosynthetic efficiency and productivity (20-30 fruits/plant; 2-5 gr/fruit), continuous flowering, high density cultivation

(100 plants/m2), good performances in soilless conditions. This cultivar has been engineered to enhance anthocyanin content in whole plant, through the ectopic expression of a transcription factor. In fact, it is generally assumed that anthocyanins are a powerful antioxidant molecule able to protect plant from Reactive Oxygen Species induced by abiotic stresses such as those induced by LEO (Low Earth Orbit) conditions. A 12-Unit CubeSat mission has been conceived by a research team from both Sapienza - University of Rome and ENEA (Italian National Agency for New Technologies, Energy and Sustainable Economic Development) for supporting the MicroTom cultivation in space, attempting a complete seed-to-seed life cycle. The spacecraft will consist of an autonomous biological unit, with a dedicated Environmental Control and Life Support System. During the mission, life parameters will be controlled and fine-tuned to improve yield and quality of production. To verify plant health status during the mission, the on-board instrumentation will be devised to control temperature, relative humidity, air pressure and gas composition, pH and electric conductivity of nutrient solution, Photosynthetically Active Radiation, Normalized difference vegetation index and radiation dose. Finally, plant growth and health will be monitored by on-board cameras. The mission could represent the first example of a plant growing in an unmanned spacecraft. In the present paper Micro-Tom characteristics, design of the 12-U CubeSat and expected plant performances, as well as possible benefits for human health during future interplanetary missions will be discussed.