Challenges of Life Support/Medical Support for Human Missions (8)
Challenges of Life Support/Medical Support for Human Missions (2) (2)

Author: Mr. Andrey Buryak
Russian Academy of Sciences / Lomonosov Moscow State University, Russian Federation,
buryak.andrej@list.ru

Dr. Yuli Berkovich
Institute of Biomedical Problems (IBMP), Russian Academy of Sciences (RAS), Russian Federation,
berkovich@imbp.ru
Mrs. Svetlana Smolyanina
Institute of Biomedical Problems (IBMP), Russian Academy of Sciences (RAS), Russian Federation,
q666666@yandex.ru
Mr. Oleg Ochkov
Institute of Biomedical Problems (IBMP), Russian Academy of Sciences (RAS), Russian Federation,
chopic@bk.ru
Mr. Sergey Lapach
National Technical University of Ukraine, Ukraine, lapach@ukr.net

MINIMIZATION OF THE EQUIVALENT SYSTEM MASS OF A VITAMIN GREENHOUSE WITH A LED LAMP FOR VARIOUS SCENARIOS OF SPACE MISSIONS

Abstract

The task of enriching the ration of crews of manned spacecraft with fresh vitamin greenery can be solved with the help of relatively small and economical space greenhouses (SG) with LED lamps. To reduce the on-board resources expenses during plants growth in the SG, a method of adaptive search optimization of plant lighting is promising. As the current optimization criterion, we took a minimum of the specific value of a part of the equivalent system mass (ESM) per a unit of grown biomass (G), which depends on the plant lighting regime. The current value of the criterion at time t_i can be written as:

$$\min G(t_i) = \min \frac{S\,(A + B\,I(t_i))}{\delta M(t_i)} \tag{1}$$

Here S-illuminated area, A and B are the cost coefficients (in terms of ESM) of the unit of planting area in SG and the unit of electric power consumed by the lamp, in kg/m^2 and kg/kW, respectively; I is the incident photons flux density; $\delta M(t_i) = k\,F(t_i)\,\delta t$ is the current crop biomass increment in a time δt, $F(t_i)$ is the current net crop photosynthesis; k is a constant. A and B substantially depend on the spacecraft design and on the space mission features - duration, number of crewmembers, etc. Examples of ESM costs are given in the list below. We calculated the coefficients in equation (1) for scenarios of 3 published space missions.

1. LEO mission: $A = 30.0$, $B = 0.13$, (Maxwell and Drysdale, 2001)
2. Moon planetary mission: $A = 20.3$, $B = 0.023$, (Drysdale and Bugbee, 2003)
3. Mars planetary mission: $A = 9.4$, $B = 0.031$, (Maxwell and Drysdale, 2001)

A test bed was built at the IMBP RAS for adaptive optimizing the illumination of Chinese cabbage crop using biological feedback on net photosynthesis. Plants were grown in a phytotron with all day

lighting. Every 15 minutes net crop photosynthesis was measuring by the rate of CO_2 reduction in the phytotron air. The microcontroller determined the value of the optimality criterion at the time of measurement and calculated the optimal lighting parameters for the subsequent search iteration. The advantage of the light modes found by the adaptive optimizer was estimated by the difference of the ESM in the phytotron crops and in the control crop, grown under the best constant light mode.