Developing a Model in situ Resource Utilization System for Oxygen Sustaining Life Support and Launch Cost Reduction for Mars

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Martian agriculture may be the most cost-effective means to develop a sustainable human life support system on Mars by employing in-situ resource utilization to convert atmospheric CO2 into O2. However, launching necessary Earth soil is prohibitively expensive, and Eichler et al. (2021) failed to germinate seeds in MGS-1, the most accurate Martian regolith simulant available. This study determined whether Phaseolus acutifolius could grow in ratios of MGS-1 and Earth-based potting soil and which substrate resulted in maximum O2 while reducing Earth-based launch mass. Plants were grown in incremental substrate ratios, and an original mathematical model was created to estimate the number of plants required to produce enough O2 to support human life while minimizing total Earth-based soil mass. Plants germinated in 0%, 25%, and 50% MGS-1 ratios. Results suggested that MGS-1 limited plant growth due to its water-retention properties. A significant difference existed between wet biomasses of plants grown in 50% MGS-1 and 0% MGS-1 ($p<.05$), with no such significant difference for the dry biomasses ($p>.05$). Plants in 50% MGS-1 allocated more resources towards obtaining water with significantly more below-ground biomass than the control ($p<.05$). Model calculations demonstrated a trend from 0% to 25% MGS-1: estimated number of required plants increased (867-1003 plants), but amount of Earth-based soil decreased (101kg-87.2kg). This trend potentially holds between 25% and 50% MGS-1 but is unclear because of large amounts of below-ground biomass. Results imply that ideal regolith content is between 50-75% MGS-1 since cost benefits of increasing regolith outweigh any decreased O2-production efficiency.

Awards Won:
Second Award of $2,000
Air Force Research Laboratory on behalf of the United States Air Force: Glass trophy and USAF medal for each recipient
Air Force Research Laboratory on behalf of the United States Air Force: First Award of $750 in each Regeneron ISEF Category