

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