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 CO_2 into O_2. However, launching the necessary Earth soil is prohibitively expensive, and Eichler et al. (2021) failed to germinate seeds in MGS-1, one of the most accurate Martian regolith simulants 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 O_2 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 O_2 to support human life while minimizing total Earth-based soil mass. Plants germinated in ratios with 0%, 25%, and 50% MGS-1. 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 to 1003 plants), but the total amount of Earth-based soil decreased (101kg to 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 the ideal regolith content of a growth substrate is between 50-75% MGS-1 since the cost benefits of decreasing the Earth-based soil used per plant outweigh the need for more plants due to decreased O_2 production.