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ALGAE AS A FEEDSTOCK FOR SPACE CROP CULTIVATION

Abstract

Sustaining plant growth in extraterrestrial environments presents significant challenges, particularly regarding soil fertility and nutrient availability. This study, conducted from Fall 2023 to Winter 2025 with NASA sponsorship, evaluates the effectiveness of algae-based biofertilizers in enhancing plant growth in synthetic Martian and Lunar regolith. Over 1,400 plant samples were tested using a controlled methodology incorporating commercial off-the-shelf (COTS) equipment and Space Resources Technologies regolith simulants to replicate extraterrestrial soil conditions.

Our findings demonstrate a statistically significant improvement in plant health, biomass production, and photosynthetic capacity when algae-derived biofertilizers were incorporated into the growth substrate. The study utilized spirulina-based feedstock, which provides essential micronutrients, growth stimulants, and nitrogen-fixing capabilities that improved plant viability in nutrient-deficient regolith environments. Results indicate that algal biofertilizers contribute to increased root development, chlorophyll content, and stress tolerance, which are essential for sustaining plant-based life-support systems in space.

A key aspect of this research is the first release of qualitative data detailing plant response metrics, nutrient assimilation, and growth differentials between Martian and Lunar regolith conditions. Additionally, our study provides insight into optimal algae-to-water ratios and delivery methods to maximize plant uptake and nutrient efficiency.

These results hold promise for in-situ resource utilization (ISRU) strategies on the Moon and Mars, particularly for closed-loop life-support systems and sustainable food production in extraterrestrial habitats. Integrating bioregenerative agriculture using algae-based solutions could reduce reliance on Earth-based resupply missions and benefit long-term planetary settlement strategies.

This work aligns with NASA's goals for sustainable exploration by providing a scalable, reproducible, and resource-efficient method for supporting plant growth in off-world environments. Future research will optimize nutrient cycling within hydroponic and aeroponic systems to further enhance space agriculture.

Keywords: Algae-based biofertilizers, Martian regolith, Lunar regolith, in-situ resource utilization (ISRU), space agriculture, *Spirulina*, closed-loop life support.