Preliminary Growth of Photosynthetic Organisms Under Synthetic K Dwarf Light

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Abstract

K dwarf stars are being proposed as new optimal hosts for habitable planets. Their long main-sequence lifetimes (15-45 Gyr) and stable luminosities out compete the harsh environment of a M dwarf. Recent experiments have demonstrated successful growth of photosynthetic organisms under a simulated K dwarf spectrum[1]. Using this as a foundation, we aim to incorporate realistic stellar activity evolution from our characterization of 580 K dwarfs[2] into experimental protocols. Using LED systems and optical filtering, our experimental design includes three environments: solar control (unfiltered), K dwarf simulation (yellow acrylic optical filtering), and aphotic control. Preliminary trials show germination and growth of all species tested.

Introduction

Outside our G2V-type Sun, M dwarfs have been the prime candidate for potentially hosting life-compatible exoplanets because of their extreme longevity and abundance. M-dwarf studies indicate the survival of photosynthetic organisms; however M-dwarfs have shorter pre-main sequence periods, low luminosity, and low mass. Because of this, habitable zones planets experience intense tidal forces coupled with extreme UV flares relative to visible light.

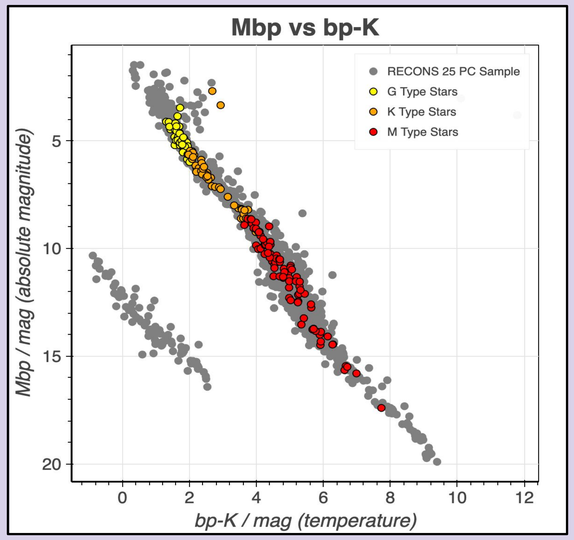

Figure 1: HR diagram of the RECONS 25 pc sample (gray) with G (yellow), K (orange), and M (red) type stars with confirmed exoplanets highlighted.

K dwarf stars are an alternative that offer higher luminosity than M stars and a longer main sequence lifetime than G stars, creating more stable habitable zones. Our spectroscopic survey of nearby K dwarfs identified activity and age indicators that characterize these stellar environments[5]. The question we seek to answer is "Can life still flourish when exposed to different solar radiation?"

The Photosynthesizers




Methods

Garden cress (*Lepidium sativum*) and rainbow radish (*Raphanus sativus*) were chosen due to their accessibility and rapid germination. To examine the potential effects of simulated K dwarf radiation on these organisms, the plants are tested in three distinct photic environments: solar (left Figure 2), K dwarf analog (right Figure 2), and aphotic control.

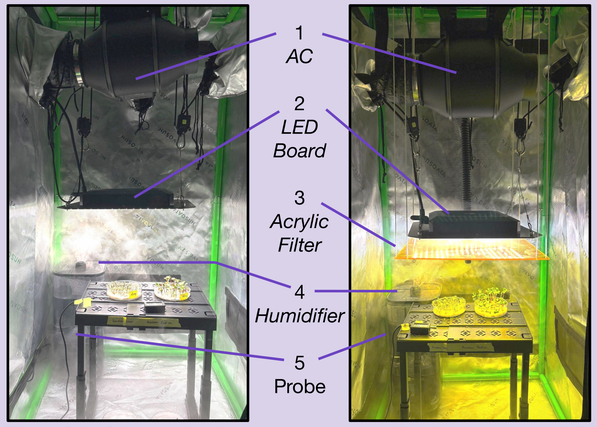

Figure 2: Left image depicts grow tent set up for the solar control. Right image depicts grow tent set up for the K dwarf analog. In both images the Garden cress can be seen on the left side and the rainbow radish on the right.

VIVOSUN Aerolight LED boards are used to mimic the Sun's spectral profile. Custom acrylic plates are then used to modify the spectrum away from the blue/green and towards the orange/red for the K dwarf analog.

We monitor garden cress and radish growth while tracking PAR intensity, humidity, and temperature using AC Infinity climate control systems.

Preliminary Results

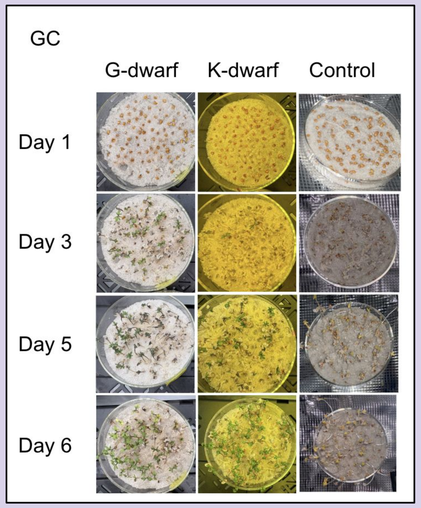

Figure 3: Six day timeline of garden cress germination in each environment

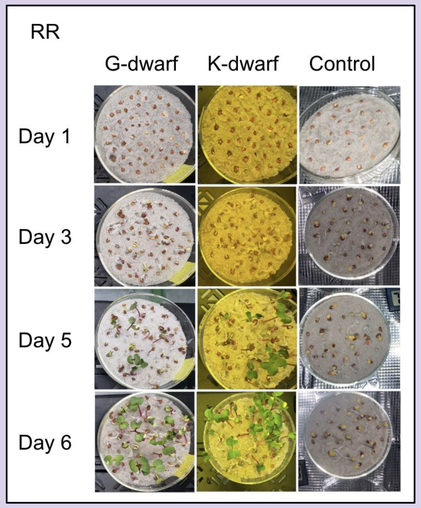

Figure 4: Six day timeline of rainbow radish germination in each environment

Visual observations show successful germination and vegetative growth under both G-dwarf (solar) and K-dwarf filtered conditions (Figures 3 and 4). By Day 6, garden cress and radish under both illumination conditions exhibited green cotyledons and robust root systems comparable between treatments. Dark controls produced pale, etiolated stems with minimal root development, confirming that filtered K-dwarf illumination maintains photosynthetic function. PAR measurements at shelf height yielded 900-1100 μmol/m^2/s (G-dwarf control) and 450-550 μmol/m^2/s (K-dwarf filtered), consistent with target spectral distributions. These preliminary results establish baseline protocols for quantitative biomass and hypocotyl measurements in future grows.

Environmental Monitoring

Germination Rate Monitoring. For Grow 5, seeds were weighed and individually placed in sand substrates. Garden cress received ~0.300 g of seed and rainbow radish received ~1.660 g of seeds. Germination rates were monitored daily across all treatments (Figure 5). By Day 6, germination reached 90-100% across G-dwarf, K-dwarf, and dark control conditions, indicating consistent environmental parameters maintained by AC Infinity climate control systems. Comparable germination rates across treatments confirm that spectral differences did not affect seed viability or initial emergence.

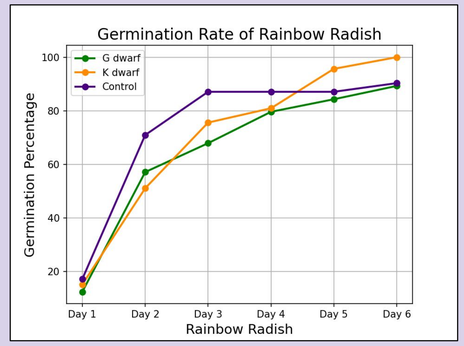

Figure 5: Line graph of the germination rates of Rainbow Radish for Control (purple), G dwarf (green), and K dwarf (Orange)

Conclusions & Future Steps

Garden Cress and Rainbow Radish demonstrated successful germination and growth under G-dwarf and K-dwarf simulated light. Significant root growth beneath the sand was comparable across both tents.

Future experiments will use **OSRAM Phytofy R light system** that allow for custom light recipes. Utilized by NASA on the ISS, this system will more accurately represent the K dwarf spectra. **Growth of organic matter will be quantified by measuring dry mass** to better evaluate photosynthetic growth proficiency under each light condition.

Figure 6: Image depicting the OSRAM Phytofy R in use by NASA.

Citations

1. Vilović, I. et al. 2024, Int. J. Astrobiology, 23, e18.
2. Hubbard-James, H.-S., Carrazco-Gaxiola, S., Henry, T.J., et al. 2026, AJ, 171, 175.
3. Cuntz, M. & Guinan, E.F. 2016, ApJ, 827, 79.
4. Hubbard-James, H.-S., Lesley, D.X., Henry, T.J., et al. 2022, AJ, 164, 174.
5. Image available at spinoff.nasa.gov. https://spinoff.nasa.gov/Spinoff2019/ee_3.html.

Acknowledgments

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