ABSTRACT In future space travel and colonization, plants and other biological systems are expected to function as an integral part of life support, providing food, potable water, and oxygen. The technical achievements that have enabled the Canadian greenhouse industry to readily grow plants during the winter are directly applicable to advanced life support (ALS) systems research. In dense plant canopies, shaded leaves represent considerable unused photosynthetic capacity which can be exploited to improve production in closed environments. By coupling Fusion Systems Solar 1000 microwave powered lights to the inner canopy of a developing soybean (Glycine max L. Merr. cv. Secord) crop. When overhead illumination of 400 - 1200 µmol m⁻² s⁻¹ PAR was supplemented with inner canopy illumination, net carbon exchange rates (NCER) were increased by 23 to 87%. With inner canopy lighting, carbon assimilation, water and oxygen production, and ethylene evolution into the closed environment were increased during leaf canopy development.

OBJECTIVES
- investigate potential value of inner canopy irradiation
- evaluate short-term net carbon exchange rates
- assess long-term water, O₂, and carbon accumulation
- monitor ethylene accumulation

PLANTS AS LIFE SUPPORT
materials required for life support are supplied from Earth

In dense plant canopies there is:
- mutual shading
- competition for light
- decreased irradiation and productivity in lower canopy
- senescence
- thus light is a limiting factor in dense plant canopies and shaded leaves represent lost photosynthetic capacity
- productivity can be enhanced by adding light to the inner canopy

PLANTS AS LIFE SUPPORT
materials required for life support are supplied from Earth

Food
Oxygen
Carbon dioxide uptake
Water

xCO₂ + 2nH₂O + light → (CH₂O)ₙ + xO₂ + nH₂O

Plants can provide:
- food
- air revitalization
- potable water
- waste processing

Light from overhead results in typical canopy architecture

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CONTROLLED ENVIRONMENT CHAMBERS

short-term NCER
Increases in the rate of carbon assimilation ranged from 23 to 87 percent between 1200 and 400 µmol m⁻² s⁻¹ of overhead irradiation

OXYGEN
Net production was increased by 92% with supplemental ICI

CARBON
30% increase in carbon accumulation at the end of 119 days of growth compared to only 11% additional energy supplied by the inner canopy lighting system

WATER
Net increase of 160% over control - water use efficiency (WUE) was lower in canopies with inner canopy irradiation

ETHYLENE
Ethylene levels reached as high as 160 ppm - the rate of production was unaltered when normalized with carbon accumulation

MORPHOLOGY
ICI plants had a more developed lower canopy with higher leaf area, and more seeds and pods

SUMMARY
Energy supplied to the inner canopy has the potential to not only improve volumetric efficiency, but can also improve carbon assimilation and the production of oxygen and water beyond what would result from overhead lighting systems alone.

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Controlled environment agriculture - enhancing productivity for long term space exploration