Physiological Responses to Reduced Pressure

Cara Ann Wehkamp, Michael Stasiak and Michael Dixon

Controlled Environment Systems Research Facility,

Department of Environmental Biology, University of Guelph

Introduction

Mars is likely the best candidate for future planetary exploration, however the Martian atmosphere is at a pressure of less than one-tenth (~0.6 kPa) of that on Earth. This large pressure differential demands that plant growth structures be isolated from the natural environment. Due to engineering constraints, reduced pressure plant growth facilities have been proposed. Decreased atmospheric pressure will reduce the structural complexity and the amount of start-up consumables, and decrease atmospheric leakage to the Martian environment. The objectives of this research are to quantify the effect of reduced pressure on the gas exchange and transpiration rates of lettuce (*Lactuca sativa* cv. Royal Green M.I. pvp).

Research Methodologies

Experiments were carried out in Hypobaric Plant Growth Chambers (HPGC) at the University of Guelph. The HPGCs are sealed systems capable of maintaining plant growth variables including atmospheric pressure.

Environmental Variables

- Pressure: 25, 50, 75, 100 kPa
- VPD: 1.0 kPa
- Partial Pressure of Carbon dioxide: 100 Pa
- Partial Pressure of Oxygen: 20 kPa
- Temperature: 25/20 ºC (day/night)
- Daylength: 16/8 hours (day/night)

Measurements

- Whole canopy net carbon exchange rates
- Transpiration

Figure 1. The HPGC (left) and 28 day old lettuce plants that were grown at 25 kPa (right).

Preliminary Results

Transpiration

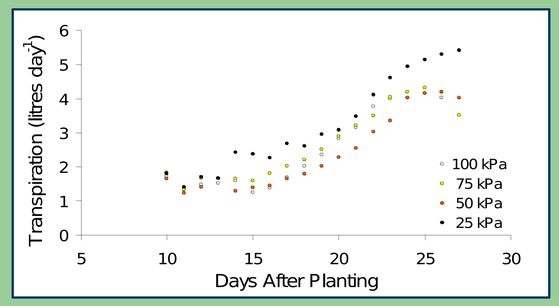

Figure 2. Whole canopy transpiration rates of lettuce at various total pressures (25-100 kPa) over a 28 day period .

Carbon Assimilation

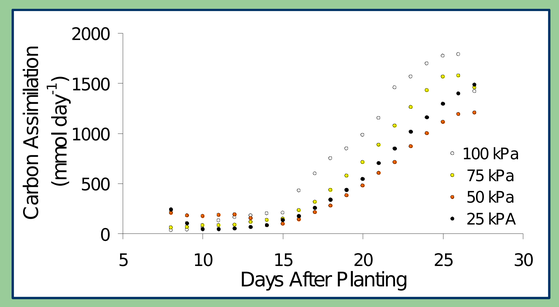

Figure 3. Whole canopy carbon assimilation of lettuce at various total pressures (25-100 kPa) over a 28 day period.

Respiration

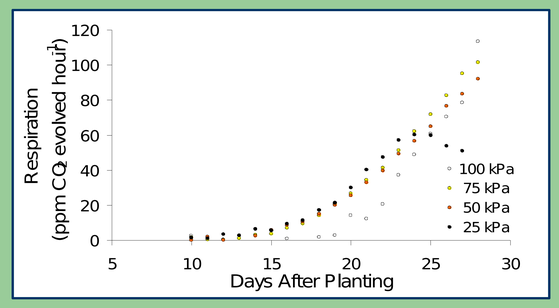

Figure 4. Respiration of a lettuce canopy at various total pressures (25-100 kPa) over a 28 day period.

Figure 2. - Transpiration

- Little variation in transpiration at pressures of 50-100 kPa.
- Increased transpiration observed at 25 kPa of total pressure.

Figure 3. – Carbon Assimilation

- Carbon assimilation decreased with decreasing pressures for the range of 50-100 kPa.
- A slight increase in carbon assimilation was observed at a total pressure of 25 kPa versus 50 kPa.

Figure 4. – Respiration

- Respiration rates similar over the range of pressures from 25-100 kPa.

Discussion

- Carbon assimilation was negatively affected by decreased atmospheric pressures.
- Observed trends imply that decreased pressure had a modest effect on transpiration and respiration over the range of pressures from 25–100 kPa.
- Increased carbon assimilation and increased transpiration at 25 kPa may be attributed to an increased gas diffusion coefficient at decreased pressures.

Conclusions

- The preliminary data suggests that if ambient partial pressures of physiologically important gases are maintained, reduced pressures have little effect on plant production for this range of atmospheric pressures.
- Further examination of carbon exchange and transpiration will aid in the establishment of an atmospheric composition that allows for reduced pressure plant growth without compromising the plant production yields required for human life support.

Acknowledgements

This research was financially supported by the CRESTech, the Ontario Ministry of Agriculture and the University of Guelph. The authors would like to thank Dr. Terry Gillespie, Dr. Youbin Zheng and Jamie Lawson for their collaborations and support.