

New Facilities and Equipment.

- Six water cooled multi-spectral LED arrays consisting of seven visible wavelengths have been installed on our small hypobaric growth chambers. The design was developed through a collaboration between CESRF, COM DEV Canada Ltd. and Intravision Group AS. Testing has (finally) started after a long development process.
- We obtained 48 PWS stem psychrometers (ICT International) for deployment in field and greenhouse environments. New features of the stem psychrometer include 10 minute resolution and wireless data collection.
- A new Shimadzu ion chromatograph was received and will replace our aging Dionex system for nutrient analysis.
- Ion selective optodes, designed in collaboration with INO and the Canadian Space Agency, were received and are currently undergoing testing.
- A remote fluorescence imaging sensor equipped with a liquid crystal tuneable filter was developed and tested in conjunction with the Canadian Space Agency and the University of Florida. It is capable of providing spectral imaging of GFP (505-525nm), chlorophyll (650-670nm) and NDVI (720-740nm). Initial testing at reduced pressure with *Arabidopsis* took place in the spring of 2012, and will continue in the spring of 2013.
- We received six 390 Watt VividGro White and VividGro Purple LED systems from Lighting Science Group Corporation. They are undergoing testing with a variety of crops in the Grodzinski lab photosynthesis systems.

Unique ~~Plant~~ Insect Responses.

Low pressure experiments on bumblebees designed to investigate their suitability as pollinators in reduced pressure plant growth environments (Moon, Mars) demonstrated the tenacity of these insects to get the job done. When the atmospheric pressure was too low to fly, the bumblebees walked to their food source. As with plants, the limiting factor to activity under reduced pressure was the availability of oxygen.

Impact Statements.

Technology transfer: Four canopy scale controlled environments for the measurement of photosynthesis were designed for Syngenta Biotechnology Inc. under a research license agreement and were delivered to their new greenhouse facility in Raleigh's Research Triangle Park in late 2012. The 1.6 m² (growing area) growth chambers were constructed by Angstrom Engineering (Kitchener, Ontario, Canada) and are closed systems that will allow the precise measurement of photosynthesis and transpiration in a variety of crops.

Communication: Tomatosphere, an educational outreach project that involves approximately 15,000 Canadian classrooms, is in its 11th year and



has just won the prestigious NSERC award for the promotion of Science in Canada. In the 2013 program, students will grow tomatoes from two sets of seeds, control and primed. Past seed sets have included seeds flown on ISS or exposed to a variety of “Mars” conditions.

Published Written Works

Bamsey, M., T. Graham, C. Thompson, A. Berinstain, A. Scott, M. Dixon. 2012. Ion-Specific nutrient management in closed systems: the necessity for ion-selective sensors in terrestrial and space-based agriculture and water management systems. *Sensors*, 12(10): 13349-133912.

Nardone, E., Kevan, P.G., Stasiak, M.A., Dixon, M. 2012. Atmospheric pressure requirements of bumblebees (*Bombus impatiens*) as pollinators of Lunar or Martian greenhouse grown food. *Journal of the American Society for Gravitational and Space Research*, 26(2): 13-21.

Bamsey, M., Berinstain, A., and Dixon, M. 2012. Development of a potassium-selective optrode for hydroponic nutrient solution monitoring. *Analytica Chimica Acta*, 732: 72-82.

Hüner, N. P. A., and B. Grodzinski. 2011. "Photosynthesis and photoautotrophy." *Comprehensive Biotechnology* 1:315-322

Iqbal, M. J., Goodwin, P. H., Leonardos, E. D. and Grodzinski, B. 2012. Spatial and temporal changes in chlorophyll fluorescence images of *Nicotiana benthamiana* leaves following inoculation with *Pseudomonas syringae* pv. *tabaci*. *Plant Pathology*, 61: 1052–1062