Controlled Environment Systems Research Facility

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2008 Station Report to the NCERA-101 Committee

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1. **New Facilities and Equipment**

8 custom-designed, computer controlled environment growth chamber systems incl. leaf and whole plant gas exchange systems, temperature controls from - 20 to +40ºC, irradiance from complete darkness to 80% full sunlight, and CO2 from sub-ambient to 5000 µmol m-1. Oxygen sensor (Apogee); Prototype plant growth chamber, 5m2 production area for staged culture without breach of atmospheric seal, outfitted with EC/pH, IRGA, pressure, air flow, PAR. Compost Tea Brewer, Oscilloscope, Viasala Temperature R/H meter.

2. **Unique Plant Responses**.

Early results indicate that direct root zone application of aqueous ozone in irrigation water can reduce the incidence of root pathogens without damaging the host plant. Ozone shows promise for controlling *Marchantia polymorpha*, potentially leading to an environmentally sound control strategy for nursery and Greenhouse operators.

Wheat, radishes and lettuce were grown for 21 days at 97 or 33 kPa total pressures and subjected to a catastrophic pressure drop to ~1.5 kPa for 30 minutes. Fresh and dry mass means for each species demonstrated no statistical difference between controls and plants exposed to the pressure drop. Study performed with Ray Wheeler, NASA Biological Sciences Office, Kennedy Space Center.

Two natural products, antirrhinoside and antirrhide were found to be early photosynthates in snapdragons. At varying temperatures the antirrhinoside was mobile accumulating in developing flowers. Collected data supports that antirrinoside significantly modified the feeding behaviour of two generalist herbivores. Together these studies provide the first evidence of a possible role of this natural compound in an ornamental in insect and pest defence.

Accumulation of important secondary metabolites, several dominant flavour precursors (RCSOs) of onion species such as leeks are altered by photoperiod and growth conditions in CES. These data show that onion flavours can be manipulated in CES.

3. **Accomplishment Summaries**.

Early diagnosis of plant pathogens is possible by remote sensing of the plant. The tools developed at the UoGuelph include 3D imaging and chlorophyll fluorescence monitoring, both of which lend themselves to computer control systems in controlled environments (CES).

The higher plant chamber prototype for the MELiSSA Pilot Plant is undergoing extensive testing in preparation for shipment. Studies on the evaluation of red spring wheat varieties conducted at the UoGuelph have totalled over 500 days of serial closure. The experiments

quantified varietal characteristics such as net carbon exchange rate, proximate and mineral composition, yield and partitioning.

Reduced Atmospheric Pressure in Radish: A comprehensive study of the effects of hypobaria (10-97 kPa) on the growth and development of radish (*Raphanus sativa* L. cv. Cherry Bomb II) has recently been completed at the UoGuelph. Radishes were grown from seed in the Hypobaric Plant Growth Chambers for a period of 21 days. The results suggest that plant adaptation responses permit conventional growth at reduced pressures.

4. **Impact Statements**.

For over 25 years UoG has offered viable solutions regarding fine control of CES environments that include levels and timing of artificial lighting, CO2 enrichment, temperature, humidity, nutrient recycling and disease management of plants. Currently we are developing and testing sensors to help engineer a new generation of autonomous systems. In addition, new crop variants with lower light tolerance, better disease resistance and potential bioproduct synthesis offer new competitive advantages to our greenhouse industries that have expanded both domestically and as exporters in spite of stiff international competition.

A long-term objective at UoG in collaboration with NASA's Kennedy Space Center is to determine the lowest pressure and O2 content for plant-based biological life support on the moon and Mars to reduce the mass and energy requirements for such systems. So far the teams have shown total pressure (10KPa) and O2 pp (5KPa) thresholds for vegetative production.

Another, long-term objective is to understand and ameliorate the negative effects that climate change may have on biological systems and our economy that is plant based. The current focus of partnering teams such as those at the "Biotron" at UWO is testimony that knowledge and equipment we have helped develop to better serve basic plan science, increase competitiveness of our greenhouse industries and extend international space exploration in renewable life support can also be utilized for predicting ecological responses in a changing Earth's climate.

Plant pest species and microbial plant pathogens are a serious concern in a production system. Recent results at UoGuelph indicate that aqueous (dissolved) ozone can be an effective root pathogen control agent as well as a potential control agent for the plant pest *Marchantia polymorpha*, a common greenhouse and nursery pest. Significant work has also been undertaken to employ ozone as a control strategy for the economically devastating plant pathogen *Phytopthora ramorum* (Sudden Oak Death). The development of the application and control strategies to safely and effectively apply aqueous ozone in a range of production strategies is not only key to helping Canadian farmers compete globally, it is also an important step in reducing our reliance on potentially toxic chemical pesticides.

5. **Published Written Works**.

Refereed Journal Articles

Beninger, C.W., R.R.Cloutier, and B.Grodzinski, 2008. The iridoid gulucosides of Antirrhinum majus L. and their differential effects on two generalist insect herboivores. J. Chem. Ecol. (in press).

Cayanan, D., Zheng, Y., Chong, C., Zhang, P., Llewellyn, J., and Dixon, M. 2008. The Application of Chlorination Technology in Disinfecting Nursery Irrigation Water -- A Field Study. HortScience (Submitted).

Lanfang, H.L., Bisbee, P.A., Richards, J.T., Birmele, M.N., Prior, R.L., Perchonok, M., Dixon, M., Yorio, N.C., Stutte, G.W., Wheeler, R. 2008. Quality characteristics of the radish grown under reduced atmospheric pressure. Advances in Space Research. 41 754-762.
Zheng, Y., Huber, J., Zhang, P. and Dixon, M. 2008. Searching for recyclable or biodegradable growing media. Acta Horticulturae (In press).

6. **Scientific and Outreach Presentations**

Cayanan, D., Lawson J., Simpson J., Wang L., Dixon, M. and Zheng, Y. 2008. Optimizing Greenhouse Irrigation: Wireless Soil Moisture Sensors and Intelligent Irrigation Scheduling. Flowers Canada (On) Research Symposium, Niagara Horticultural College, Ontario, Canada.
Dahal, Keshav, B Grodzinski, N Hüner. 2007 Photosynthetic Response of Winter and Spring Cereals to Elevated CO2. Proc. 2nd Ann Gen Meet of the Green Crop Network. Univ of Ottawa, Ottawa, Canada.
Dixon, M. 2008. Biological Life Support for the Exploration of Space, University of New England, Armidale, New South Wales, Australia
Grodzinski B. 2007. Identification and characterization of plant variants exhibiting enhanced photosynthesis and biomass production under elevated CO2 high temperature and drought. NSERC -Green Crop Network, Proc. 2nd Annual General Meeting. University of Ottawa, Ottawa, Canada.
Thirsk, R., M. Dixon. 2007. Tomatosphere. Moon, Mars and Beyond. Technology for Life Support in Space. Royal Agricultural Winter Fair, Toronto, Ontario.
Zheng, Y., Cayanan, D., Dixon, M. 2008. Using chlorination technology to disinfect irrigation water. Landscape Ontario 2008 Growers' Short Course. Royal Botanic Gardens, Burlington, Ontario, Canada.

7. **Other relevant accomplishments and activities.**

The CESRF was awarded one of only two UoGuelph allocations for TSTOP (Teachers' Science and Technology Outreach Program) from the Ministry of Research and Innovation. The project sponsored a grade 10 teacher who spent 4 wks (Aug) in a hands-on environment in the CESRF working with local and international scientists. The teacher gained knowledge in horticultural management, plant physiology, biophysics and bioregenerative life support that was transferred to their classroom using physics demonstrations and plant growth experiments. As part of the program, the teacher brought students (~60) to the CESRF on two separate occasions for a full day of hands on lab experiments in the CESRF including UoGuelph tours.

The CESRF has offered a full semester course as part of the UoGuelph's first year seminar series. The course is the backdrop of the CESRF's continuing work in bioregenerative systems development for space application as a means to improve student communication, numeracy, bibliographic research and team work skills. The course is now in its 3rd year of offering and is expected to be offered in each of the fall and winter semesters starting in 2008.

The Tomatosphere educational outreach program has grown from an involvement of 2700 classes in 2001 to 9865 classes (to date) for 2008, with the expectation that this number will reach 11 000 by May 2008. Four new units of study have been added to the science curriculum already in place - two on nutrition, one on long-term survival in space and one on weather and Mars. Canadian classes still dominate the project - about 70% of the classes enrolled, with new enrolment from the United States, and several international participants including South Korea, Pakistan, India, Israel, France, New Zealand and Australia.
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