

1. New Facilities

An open-roof greenhouse (Van Wingerden, MX-II, four gutter-connected bays and covered with double poly, 58 x 60 feet floor area) was constructed at a research farm near campus. The roof sections hinge at the gutter and open at the ridge. The greenhouse environment is controlled with an Argus control system. Inside and outside environment is monitored continuously and the data is used by Dr. Sadanori Sase (National Research Institute of Agricultural Engineering in Tsukuba, Japan) for the development of a natural ventilation model.

2. Monitoring Sensors and Measurement Instruments

Design and Construction of Growth Chambers for Continuous, Real-Time Measurement of Plant Photosynthesis and Transpiration by Gas Analysis

In order to provide non-destructive growth data for crop modeling efforts, four environmentally controlled plant growth chambers have been constructed to monitor canopy net photosynthesis and dark cycle respiration rates of various advanced life support food crops (soybean, potato, and tomato). Final testing of the baseline environmental control for the photosynthetic chambers was completed. Chamber air temperature was successfully maintained, at desired values within the soybean plant canopy, and above the canopy for air exchanges ranging from 1 to 5 volume changes per minute (0.43 to 2.2 m³ per minute). System calibration was evaluated using empty chamber and carbon (C) recovery tests. The latter tests were conducted by placing a known amount of NaHCO₃ in each chamber and adding 0.1N Nitric acid at a slow rate. Experiments are initially designed to produce data for the short- and long-term effects of air temperature, atmospheric carbon dioxide concentration, and irradiance on CO₂ exchange rates for soybean.

3. Workshops/Colloquia/Symposia

A CCEA Conference, “**ACESYS III: From Protected Cultivation to Phytomation**” was held on Friday July 23, 1999 in New Brunswick, NJ, in honor of Professor William J. Roberts’ retirement from Rutgers University. This one-day event included a Phytomation Special Lectures Forum, a “visioning” session, and an evening banquet. The conference was chaired by Dr. Tadashi Takakura, Nagasaki University, Japan, and Dr. K.C. Ting, Rutgers University, USA. A conference proceedings was prepared and is available from the Bioresource Engineering Department.

4. Cooperative Interdisciplinary Projects (part of the NASA NJ-NSCORT project)

Nutrient Delivery System for Root Crop production in Micro-gravity Salad Machine

The purpose of this project is to develop methods and equipment for use in the salad machine. The work has been broken down into five separate sections, each with a research project. The five projects are: (1) radish root manipulation, (2) periodic leaf removal from lettuce plants, (3) development of a wicking sheet nutrient delivery system, (4) carrot production, and (5) strawberry on a porous tube nutrient delivery system.

Crop Modeling for Multiple Crop Production and Control for Advanced Life Support Systems

Hydroponic experiments with soybean and white potato have been conducted in environmental growth chambers. Two crop life-cycle experiments have been completed for soybean (cv. Hoyt) under near-ambient (425 vpm) and elevated (1100 vpm) atmospheric CO₂ concentrations, and with two irradiance treatments (450 and 800 μmol PAR m⁻² s⁻¹) per experiment. For white potato (cv. Norland), two 56-day and one 105-day experiment were completed for nominal environmental conditions (irradiance = 407 μmol m⁻² s⁻¹, light cycle–dark cycle temperature regime of 20-16°C, [CO₂] = 1020 vpm, photoperiod = 12 h, and 70% relative humidity). Existing mathematical models, developed for field conditions (e.g., SUBSTOR for white potato), are being modified for use in Advanced Life Support type environments. Multivariate polynomial regression analyses were used to develop a computerized controller logic, which can compensate for the effects of average daily air temperature, light intensity, and CO₂

concentration on crop growth and development. An optimal point-wise controller was developed for a simple growth model to demonstrate the viability of this approach.

Object-oriented analysis and modeling of closed plant production systems

A crop production model for biomass production in an advanced life support system for long duration human space exploration was developed. The JAVA based computer model is capable of calculating crop yield, inedible plant material, water transpiration, power usage, labor requirements, etc. for various crop mixes and scheduling scenarios. A set of so-called foundation classes was developed to describe the various components of closed plant production systems. These foundation classes include *Automation*, *Culture_Plant*, *Culture_Task*, *Culture_Facility*, *Environment_Rootzone*, *Environment_Aerial*, *Environment_Spatial*, and *Shell*. The biomass production model can be modified for simulating other closed plant production systems.

5. Recent Publications

- Choi, C.Y., W. Zimmt, and G.A. Giacomelli. 1999. Freeze and frost protection with aqueous foam – Foam development. *HortTechnology* 9(4): 654-661.
- Choi, C.Y., and G.A. Giacomelli. 1999. Freeze and frost protection with aqueous foam – Field experiments. *HortTechnology* 9(4): 662-667.
- Fleisher, D.H., J. Cavazzoni, G. A. Giacomelli, and K.C. Ting. 1999. Modification of SUBSTOR for hydroponic, controlled environment white potato production. ASAE paper No. 994120. ASAE, 2950 Niles Road, St. Joseph, MI 49085-9659, USA. 11 pp.
- Fleisher, D.H., K.C. Ting, M. Hill, and G Eghbali. 1999. Top modeling of biomass production component of ALSS. The 29th International Conference on Environmental Systems, Society of Automotive Engineers, Inc. ICES99CD, Paper No. 1999-01-2041. 9 pp.
- Goudarzi, S., and K.C. Ting. 1999. Top level modeling of crew component of ALSS. The 29th International Conference on Environmental Systems, Society of Automotive Engineers, Inc. ICES99CD, Paper No. 1999-01-2042. 8 pp.
- Kang, S., and S.R. Delwiche. 1999. Moisture diffusion coefficient for a single wheat kernel during moisture tempering process. ASAE paper No. 996050. ASAE, 2950 Niles Road, St. Joseph, MI 49085-9659, USA. 13 pp.
- Kang, S., J.A. Hogan, and K.C. Ting. 1999. Simulation model of waste processing and resource recovery components in an advanced life support system. ASAE paper No. 993097. ASAE, 2950 Niles Road, St. Joseph, MI 49085-9659, USA. 16 pp.
- Kim, Y. 1999. Machine Vision Guided Sensor for Plant Temperature Sensing. M.S. Thesis, Rutgers University Libraries, New Brunswick, NJ, USA. 106 pp.
- Kim, Y., P.P. Ling, N. Kondo, and K.C. Ting. 1999. Development of a robotic camera system for 3-D sensor positioning. ASAE paper No. 993075. ASAE, 2950 Niles Road, St. Joseph, MI 49085-9659, USA. 14 pp.
- Kondo, N., M.H. Jensen, T. Kozai, L.D. Albright, J.C. Sager, H. Murase, Y.E. Chu, D.R. Mears, K.C. Ting, and G.A. Giacomelli. 1999. Proceedings of the ACESYS III Forum: From protected cultivation to phytomation. Rutgers University, Cook College, New Brunswick, NJ. July 23, 1999. 128 pp.
- Roberts, W.J. 1999. Open-roof greenhouse scenario. ASAE paper No. 995009. ASAE, 2950 Niles Road, St. Joseph, MI 49085-9659, USA. 7 pp.
- Rodriguez, L.F., S. Kang, J.A. Hogan, and K.C. Ting. 1999. Top-level modeling of waste processing and resource recovery component of ALSS. The 29th International Conference on Environmental Systems, Society of Automotive Engineers, Inc. ICES99CD, Paper No. 1999-01-2044. 7 pp.
- Rodriguez, L.F., B.J. Sauser, and K.C. Ting. 1999. Information flow analysis on the lunar mars life support test project. The 29th International Conference on Environmental Systems, Society of Automotive Engineers, Inc. ICES99CD, Paper No. 1999-01-2046. 6 pp.

6. Internet Sites

<http://www.rci.rutgers.edu/~biorengg>; <http://nj-nscort.rutgers.edu/acesys>