REPORT FOR THE NCR-101 MEETING, SEPTEMBER 9-12, 2001
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1. New Facilities

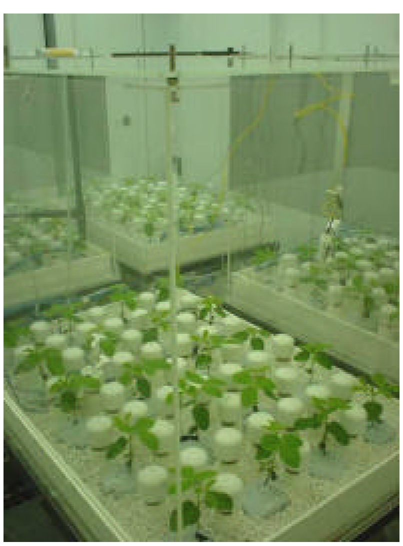
Open-roof greenhouse

An open-roof greenhouse (Van Wingerden Greenhouse Company, MX-II, four gutter-connected bays, 17.7 by 18.3 m floor area) is undergoing a renovation process. Plastic heating pipes were embedded in a new ebb and flood floor irrigation system. All side-walls of the greenhouse were outfitted with 8 mm thick, twin-walled acrylic panels. Roof segments are clad with double poly film. In addition to the roof vents, two motorized side vents were installed along the east and west sidewalls. These side vents will allow for ventilation during high wind or rainy conditions. A gas-fired, hot-water boiler will be installed to supply warm water to the greenhouse floor, and to a perimeter and an overhead heating loop.

Ebb and flood floor irrigation system

Two independently operated ebb and flood floor sections (13.7 by 7.3 m each) were installed in the open-roof greenhouse. The nutrient solutions will be stored in two separate underground concrete tanks (5,678 L each). Submergible pumps pump the stored nutrient solutions onto the floor and pneumatic valves will allow the nutrient solution to return to the storage tank after the irrigation cycle is completed. Each nutrient solution tank is equipped with an automatic (time delayed) supply of make-up water. Fertilizer injectors will add the appropriate amount of nutrients to the make-up water.

2. Sensors and Instruments



Continuous, Real-Time Measurement of Plant Photosynthesis and Transpiration by Gas Analysis for a Soybean Crop (NJ-NSCORT)

In order to provide non-destructive growth data useful for crop modeling efforts, four environmentally controlled plant growth chambers (located inside a walk-in plant growth chamber and each measuring 91 x 64 x 76 cm, L x W x H) have been used to monitor canopy net photosynthesis and dark cycle respiration rates of soybean. Ninety-day experiments were conducted to produce data including short and long-term effects of air temperature, atmospheric carbon dioxide concentration, and irradiance on CO_2 exchange rates. The collected data are being analyzed as part of Konomi Kumasaka's M.S. thesis project. Additional experiments with lettuce are being conducted. One of the biggest challenges during the experiments proved to be the proper operation of the gas analyzer (ADC 2250 Gas Analyzer, ADC BioScientific Ltd., Hoddesdon, England), particularly during the 90-day soybean experiments.

3. Cooperative/Interdisciplinary Projects

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

As part of David Fleisher's PhD dissertation research, a computerized algorithm was developed to simulate and compensate for effects of environmental perturbations on production and scheduling of hydroponically grown wheat, soybean, and white potato in controlled environments. A white potato field model, SUBSTOR, was modified based on experimental data of potato growth in growth chambers. The modified SUBSTOR model was combined with similar models for wheat and soybean and used to simulate crop growth and development data. A methodology was developed to fit this data using Multivariate Polynomial Regression (MPR). A model-based predictive control algorithm was constructed using the MPR crop models to predict future crop response. The algorithm was integrated with a Visual Basic computer program to simulate crop growth and compensate for disturbances in light intensity, air temperature, and CO_2 concentration.

Top-level Modeling of Advanced Life Support Systems and Component Systems

As part of Luis Rodriguez' PhD dissertation research, efforts were undertaken towards the development of acceptable, flexible, and dynamic mathematical computer modeling tools capable of system level analysis. Object oriented techniques were adopted to develop a top-level model of an advanced life support system such as a space station or a planetary base. An advantage of this approach is that object oriented abstractions of systems are inherently modular in architecture. Thus, models can initially be somewhat simplistic, while allowing for incorporation of adjustments and improvements. In addition, by coding the model in Java, the model can be implemented across the Web, greatly encouraging the utilization of the model. The sub-models of the overall advanced life support system model include Crew, Biomass Production, Waste Processing and Resource Recovery, and Food Processing and Nutrition. At present, the BP and WP&RR sub-models are the most complete, and are the first to be incorporated. This constitutes the initial step towards the integration of all the sub-models to form an overall top-level model of an entire advanced life support system.

Supplemental Lighting for Plug Production

A collaborative research project under the leadership of Dr. Paul Fisher (University of New Hampshire) was initiated. The project investigates the economic feasibility of supplemental lighting (HPS) for plug production and specifically studies the effects of supplemental lighting on production time and post-production plant quality. Part of the research is conducted at a commercial greenhouse operation in Allentown, New Jersey (Kube Pak, Bill Swanekamp).

4. Committees and sub-committees served

NE-164 Regional Committee on Decision Support for Design and Control of Plant Growth Systems: A.J. Both, Chair (2001)

CEA Advisory Board, Cornell University: A.J. Both, member

SE-303 Committee on Environment of Plant Structures, ASAE: David Fleisher, Chair (2001)

5. Recent Publications

Both, A.J., E. Reiss, D.R. Mears, and W.J. Roberts. 2001. Open-roof greenhouse design with heated ebb and flood floor. Presented at the International ASAE meeting, Sacramento, CA. ASAE paper No. 01-4058. NJAES paper No. P-03232-15-01. 13 pp.

Both, A.J., D.E. Ciolkosz, L.D. Albright. 2001 (accepted). Evaluation of light uniformity undemeath supplemental lighting systems. Submitted to Acta Horticulturae.

Ciolkosz, D.E., A.J. Both, and L.D. Albright. 2001 (accepted). Selection and placement of greenhouse luminaires for uniformity. Submitted to Transactions of the ASAE.

Cavazzoni, J., F. Tubiello, T. Volk, and O. Monje. 2001 (in review). Modeling the effect of diffuse light on canopy photosynthesis in controlled environments. Submitted to Acta Horticulturae.

Fleisher, D.H., H. Baruh, and K.C. Ting. 2001. Model-based predictive control for biomass production in advanced life support. Presented at the IFAC-CIGR Workshop on Intelligent Control for Agricultural Applications, August 22-24, Bali, Indonesia. NJAES Publication No. D-70501-10-01.

Fleisher, D.H., S. Kang, K.C. Ting. 2001. Software for multiple crop production in advanced life support systems. Presented at the International ASAE meeting, Sacramento, CA. ASAE paper No. 01-4084. NJAES paper No. P-70501-08-01.

Fleisher, D.H. 2001. Modeling for multiple crop production and control in advanced life support systems. Ph.D. Dissertation. Rutgers University Libraries. NJAES Publication No. T-70501-16-01.

Fleisher, D.H. and K.C. Ting. 2001 (in review). Modeling and control of plant production in advanced life support systems. Submitted to Acta Horticulturae. NJAES Publication No. P-70501-07-01.
Fleisher, D.H. and H. Baruh. 2001 (in review). An optimal control strategy for crop growth in advanced life support systems. Submitted to Life Support & Biosphere Science.
Fleisher, D.H. and K.C. Ting. 2000. Object-oriented analysis and modeling of closed plant production systems. In Transplant Production in the 21st Century, C. Kubota and C. Chun, editors. Kluwer Academic Publishers, The Netherlands, pp. 53-58.
Fleisher, D.H. and H. Baruh. 2000. Control of crop growth in advanced life support systems. In Proceedings of Agricontrol 2000 - International Conference on Modeling and Control in Agriculture, Horticulture, and Post-Harvest Processing, Wageningen, the Netherlands.
Fleisher, D.H. and K.C. Ting. 2000. Models for scheduling and control of crop production within advanced life support systems. In Proceedings of Agricontrol 2000 - International Conference on Modeling and Control in Agriculture, Horticulture, and Post-Harvest Processing, Wageningen, the Netherlands, pp. 2-15.
Fleisher, D.H., Cavazzoni, J., Giacomelli, G.A., and K.C. Ting. 2000. Adaptation of SUBSTOR for hydroponic controlled environment white potato production. Presented at the International ASAE Meeting, Milwaukee, WI. ASAE Paper No. 004089.
Giacomelli, G.A., S.A. Garrison, M. Jensen, D.R. Mears, J.W. Patterson, W.J Roberts, and O.S. Wells. 2000. Advances in plasticulture technologies 1977–2000. Proceedings of the 15th International Congress for Plastics in Agriculture, Hershey, PA Sept. 23-27, 2000. NJAES Paper No. P-03130-20-00.
Gottdenker, J.S. 2001. Supplemental lighting strategy for greenhouse strawberry production. M.S. thesis. Rutgers University Libraries. 100 pp.
Hsiang, H., S. Kang, A.J. Both, and K.C. Ting. 2001. Analysis tool for food processing and nutrition (FPN) subsystem in advanced life support system (ALSS). Presented at the International ASAE meeting, Sacramento, CA. ASAE Paper No. 01-3020. NJAES Paper No. P-70501-12-01. 17 pp.
Hsiang, H., S. Kang, and K.C. Ting. 2000. Simulation of food processing and nutrition in advance life support system. Presented at the International ASAE Meeting, Milwaukee, WI. ASAE Paper No. 006002.
Jones, H. and J. Cavazzoni. 2000. Top-level crop models for advanced life support analysis. SAE paper No. 2000-01-2261, 30th International Conference on Environmental Systems (ICES), Toulouse, France, July 10-13, 2000.
Kang, S. and A.J. Both. 2001. A management information system for food nutritional analysis and biomass production in an ALSS. Presented at the International ASAE meeting, Sacramento, CA. ASAE Paper No. 01-3021. NJAES Publication No. P-70501-11-01. 10 pp.
Kang, S. and J. Hogan. 2001. Optimization of feedstock composition and pre-processing for composting in advanced life support systems. Presented at the ICES 2001 Meeting, Orlando, FL. SAE Technical Paper No. 2001-01-2297. NJAES Publication No. H-70501-05-01. 8 pp.
Kang, S., Y. Ozaki, K.C. Ting, and A.J. Both. 2000. Automation for biomass production within advanced life support systems. Second IFAC/CIGR International Workshop on Bio-Robotics, Information Technology and Intelligent Control for Bioproduction Systems, Sakai, Osaka, Japan (November 25-26, 2000).
Kang, S., K.C. Ting, and A.J. Both. 2000. Systems studies and modeling of advanced life support system. The Third International Conference on Agricultural Machinery Engineering. Seoul, Korea (November 13-16, 2000). Volume III: 623-631.
Kang, S., Y. Ozaki, K.C. Ting, and A.J. Both. 2000. Identification of appropriate level of automation for biomass production systems within an Advanced Life Support System. Presented at the International ASAE Meeting, Milwaukee, WI. ASAE Paper No. 003075.
Lefsrud, M. 2001. Design and evaluation of nutrient delivery systems and plant management for the salad machine. M.S. thesis. Rutgers University Libraries. 182 pp. NJAES Paper No. T-70501-17-01.
Mears, D.R. and A.J. Both. 2000. Insect exclusion from greenhouses. Proceedings of the 15th Workshop on Agricultural Structures and ACESYS (Automation, Culture, Environment, and Systems) IV Conference. December 4-5, Tsukuba, Japan. pp. 18-26. NJAES Paper No. P-03130-23-00.
Mears, D.R. and A.J. Both. 2001. Insect screening and positive pressure ventilation for tropical and subtropical greenhouse facilities. Keynote Presentation and Proceedings of The International Symposium on Design and Environmental Control of Tropical and Subtropical Greenhouses. ISHS, Taichung, Taiwan. April 15-18 2001. NJAES Paper No. P-03130-06-01.
Rodriguez, L.F., C. Finn, S. Kang, and J. Hogan. 2001. Modeling of a composting system within BIO-Plex. Presented at the ICES 2001 Meeting, Orlando, FL. NJAES Publication No. H-70501-09-01. 11 pp.
Rodriguez, L.F., S. Kang, and K.C. Ting. 2000. Top level modeling of an ALSS utilizing object oriented techniques. Manuscript Number F4.3-0003. 33rd COSPAR Scientific Assembly. Warsaw, Poland. (July 16-23, 2000).
Roberts, W.J. 2000. Greenhouse technology – Open roof design. Proceedings of the 15th International Congress for Plastics in Agriculture, Hershey, PA Sept. 23-27, 2000. NJAES Paper No. P-03130-09-00.
Roberts, W.J. 2000. Resource efficient open-roof greenhouses. Proceedings of the 15th Workshop on Agricultural Structures and ACESYS (Automation, Culture, Environment, and Systems) IV Conference. December 4-5, Tsukuba, Japan. pp. 9-17. NJAES Paper No. P-03130-24-00.

6. Internet Site

http://aesop.rutgers.edu/~horteng