THE UNIVERSITY OF
ARIZONA

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1. Impact Nuggets

- The University of Arizona developed a low temperature storage method for grafted cantaloupe seedlings (up to four weeks) that would save labor requirement of grafting propagators significantly.
- We have developed a computer vision guided crop sensing and monitoring system and a methodology to monitor nutrient deficiency which could eventually save labor to monitor crop quality and yield, as well as improve resource use efficiency.
- We have designed and developed the ACCORDION photobioreactor for production of photosynthetic algae and plant cell, tissue or organ cultures. We have confirmed in green algae that growth and chlorophyll content can be significantly increased using the same amount of light energy by implementing a composite lighting profile. We will be testing a prototype for the spectral phytometric light meter, a four-in-one light meter that measures and reports radiation in phytometric, quantum, radiometric and photometric units.

2. New Facilities and Equipment

● Dr. Kacira continues to work on advancing the sensing and control lab at CEAC to assess plant growth, quality and health. A masters student has been working on development of a machine vision guided system. Initially, the monitoring system was used to autonomously monitor textural, color, and temporal features of lettuce crop growing in a floating hydroponics system for detection of tipburn induced by calcium deficiency. The project continues on improving the system capability with multisensory/sensing based platform development.

● Dr. Kacira and Dr. Giacomelli with small business Sadler Machine Co. have developed a prototype inflatable greenhouse system for algae production to use for biofuels production. The system is a closed circulating system and has necessary sensor/instrumentation to both monitor alga culture (EC, pH, temperature, optical density) and aerial environment. The system is capable of controlling the rate of nutrient and CO2 injections. The capability of the system is being evaluated.

● Prototype Lunar Greenhouse (LGH): With the NASA Steckler Phase I grant, Drs. Giacomelli and Kacira with Mr. Phil Sadler (Sadler Machine Co.) has been working on further improvement of the LGH's sensor/instrumentation capabilities to monitor the system. A new weighing platform has been installed to be able to continuously monitor biomass change and crew labor time. The system is operable, instrumented, and closure experiments are about to start to evaluate water recycling, atmosphere revitalization (CO_2-O_2), biomass production with a multi-crop cable-culture production system, energy use. The project also focused on documenting the system operational requirements, capabilities and weaknesses. For more information: http://ag.arizona.edu/ceac/live/CEAC_live.htm; http://www.youtube.com/watch?v=Z-0qJ4eZhs4.

● Dr. Kubota has completed her USDA SBIR Phase I project with Dr. Takashi Nakamura (Physical Sciences Inc.). This collaborative project was to test a PSI's solar lighting system for value added transplant production. The solar lighting system consisted with solar tracking system, spectral reflectors, and fiber optical cables.

● Dr. Kubota has a small set up of strawberry raised trough culture system (Ishiguro Strawberry culture system imported from Japan) to evaluate the productivity and fruit quality of hydroponic strawberry in semi-arid greenhouse. She also evaluates the effect of crown temperature control in collaboration with Dr. Makoto Okimura (Kyushu/Okinawa Agricultural Research Center, Japan) for cultural practices and Dr. Murat Karcira for engineering analysis. The goal will be to develop root zone temperature control system/strategy for energy savings in the production.

● Dr. Joel Cuello with collaborator Prof. Gilberto da Costa of Brazil will be testing a prototype for the spectral phytometric light meter developed by the company Everfine based on Dr. Cuello and Prof. Costa's theoretical development of the phytometric system, a correct Watt-based light measurement system for plant applications. The new spectral phytometric meter is a four-in-one light meter, measuring and reporting radiation readings in all four systems of light measurement – phytometric, quantum, radiometric and photometric – and thus will meet the needs of plant growers, lighting engineers, architects, etc.

● Dr. Joel Cuello with M.S. student Joseph Ley designed and developed the ACCORDION photobioreactor for production of photosynthetic algae and plant cell, tissue or organ cultures. The ACCORDION is a vertical series of angled flat plates for optimal lighting and hydrodynamic mixing. It is currently being optimized. For more information: http://www.youtube.com/watch?v=kz99Qnp74lA.

3. Unique Plant Responses.

Dr. Joel Cuello with Ph.D. student Takashi Hoshino successfully demonstrated a 20% increase in both dry mass and chlorophyll concentration in a green algae species using a composite lighting profile. The control of conventional

lighting profile and the treatment of composite lighting profile both received equal quantities of light energy. The study confirmed in green algae the same results obtained earlier in lettuce, that is, that growth and chlorophyll content can be significantly increased using the same amount of light energy by implementing a composite lighting profile.

4. Accomplishment Summaries

Greenhouse Crop Production and Engineering Design Short Course. Eye on Economics and Energy, April 26-29, 2009. Continuing professional education short course, University of Arizona. Included a tour to EuroFresh Farms (Willcox, AZ). C. Hackathorn, J. Massey, **G. A. Giacomelli, C. Kubota, M. Kacira**, P. Rorabaugh, M. Jensen, and M. Kroggel. (***125 participants***)

Prototype Lunar Greenhouse and CEAC, Documentary video by Chip Prosser, ChipPro, LLC http://www.youtube.com/user/chippro#p/a/0/F4Dbh0nvh-4 July 2009.

New spectral phytometric meter for light measurement, reporting radiation readings in all four systems of light measurement (phytometric, quantum, radiometric and photometric), to be tested by Dr. Joel Cuello and Prof. Gilberto Costa.

ACCORDION photobioreactor for production of photosynthetic algae and plant cell, tissue or organ cultures. http://www.youtube.com/watch?v=kz99Qnp74lA

Composite lighting applied to green algae increased both growth and cholorophyll content by 20%.

5. Impact Statements

The four-week low temperature storage method developed at the University of Arizona (PI: Kubota) is estimated to increase one's propagation capacity of grafted seedlings up to 20 times without significantly increasing number of laborers. Further investigation is necessary to test various combinations of scion and rootstocks, but this will help propagators establish a sizable capacity to serve for vegetable industry in the US, as labor input and seasonal demand are considered limiting factors of the technology transfer.

6. Published Written Works

Fitz Rodríguez, E., **G. A. Giacomelli**, 2009. Yield Prediction And Growth Mode Characterization Of Greenhouse Tomatoes With Neural Networks And Fuzzy Logic. Trans ASABE Vol. 52(6): 2115-2128

Rhoades, E.B., T. Irani, M. B. Tingor, S.B. Wilson, **C. Kubota, G. Giacomelli**, and M.J. McMahon, 2009. A Case Study of Horticultural Education in a Virtual World: A Web-based Multimedia Approach. NACTA Journal, December 2009

Fitz-Rodriguez, E**., C. Kubota, G.A. Giacomelli,** M. Tignor, S.B. Wilson, M. McMahon, 2010. Dynamic modelling and simulation of greenhouse environments under several scenarios: A web-based application. Computers and Electronics in Agriculture 70(1):105-116.

Sadler, P., **G. Giacomelli**, R. Furfaro, **M. Kacira**, and R.L. Patterson. 2009. Prototype BLSS Lunar Greenhouse. SAE International Paper No. 09ICES-0250

Baeza, E., **M. Kacira**, J. P. Parra, J. C. López, J. C. Gázquez, , J. I. Montero. 2009. Validation of CFD Simulations for Three Dimensional Temperature Distributions of a Naturally Ventilated Multispan Greenhouse obtained by Wind Tunnel Measurements. ActaHorticulturae (Accepted).

Story, M., **M. Kacira, C. Kubota,** A. Akoglu, L. An. 2010. Nutrient Deficiency Detection with Machine Vision Computed Plant Features in Controlled Environments. Computers and Electronics in Agriculture (In review)

Kacira, M. and H.H. Ozturk. 2010. Energy and Exergy Efficiency of Fixed and Two-Axis Tracking Photovoltaic Panels. Progress in Photovoltaics: Research and Applications (Accepted)

Bascetincelik, A., H.H. Ozturk, K. Ekinci, D. Kaya, **M. Kacira**, C. Karaca. 2009. Strategy development and determination of barriers for thermal energy and electricity generation from agricultural biomass. Energy, Exploration & Exploitation, 27 (4): 277-294.

Bascetincelik, A., H.H. Ozturk, K. Ekinci, D. Kaya, **M. Kacira**, C. Karaca. 2009. Assessment of the applicability of EU biomass technologies in Turkey. Energy, Exploration & Exploitation, 27 (4): 225-306.

Justus, I and **C. Kubota**. 2010. Effects of low temperature storage on growth and transplant quality of non-grafted and grafted cantaloupe-type muskmelon seedlings. Scientia Horticulturae. (in press)

Matsuda, R., **C. Kubota**, M. L. Alvarez and G. A. Cardineau. 2010. Determining the optimal timing of fruit harvest in transgenic tomato expressing F1-V, a candidate subunit vaccine against plague. HortScience. (in press)

Matsuda, R., **C. Kubota**, M. L. Alvarez and G. A. Cardineau. 2009. Biopharmaceutical protein production under controlled environments: growth, development and vaccine productivity of transgenic tomato plants grown hydroponically in a greenhouse. HortScience. 44:1594-1599.

Li, Q. and **C. Kubota**. 2009. Effects of supplemental light quality on growth and phytochemicals of baby leaf lettuce. Environ. Experiment. Botany. 67:59-64.

Takakura, T., **C. Kubota**, S. Sase, M. Ishii, K. Takayama, H. Nishina, K. Kurata, and **G.A. Giacomelli**. 2009. Measurement of evapotranspiration rate in a single-span greenhouse using the energy-balance equation. Biosystems Engineering. 102:298-304.

Kubota, C. and M. Kroggel. 2010. Application of 1-MCP for long distance transportation of high quality tomato seedlings. Acta Horticulturae (submitted)

Fitz-Rodríguez, E., J. Nelkin and **C. Kubota**. 2010. Use of disposable film sensor for analyzing uniformity of daily light integral inside a greenhouse. Acta Horticulture (in press)

Kuwahara, S. and **Cuello, J.L**. 2009. Reclaimed Water and Secondary Wastewater as Alternative Growing Media for Green Algae for Biofuel Production. Journal of Energy and Environment Conference. ISSN 1941-9848. Vol. 3 (5).

5. Scientific and Outreach Oral Presentations

Cuello, J.L. 2009. Algae Biofuels: Photobioreator Design and Production Strategies. University of Cambridge, Department of Chemical Engineering and Biotechnology, Cambridge, U.K. 06/12/09.

Cuello, J.L. 2009. Algae Biofuels: Photobioreator Design and Production Strategies. University of the Philippines at Los Banos, College of Engineering and Agro-Industrial Technology,Philippines. 07/21/09.

Cuello, J.L. 2009. The Power of Algae: Strategies for Harnessing Algae as Feedstock for Biofuel Production in China. Zhejiang University, Department of Biosystems Engineering and Food Science, Hangzhou, China. 12/24/2009

G. Giacomelli. 2009. Discovery Channel, "Mile high city, urban agriculture, and vertical farms...a look at reality at EuroFresh Farms and the CEAC." Edna Sun, videographer. With David Letich, EuroFresh Farms. September 2009.

Giacomelli, G.A. 2009. Selecting Greenhouse Structures and Environments to Meet Your Production Expectations. Greenhouse Growers Association of Mexico (AMHPAC). Guadalajara, Mexico, August 26 – 28. [Invited lecture].

Kacira, M. 2009. Engineering concerns and opportunities for sustainable greenhouse systems. International Symposium on High Technology for Greenhouse Systems (GreenSys2009). University of Laval, Quebec, Canada, June 14-19. [Invited Presentation]

M. Kacira. 2009. Farm of Future. MSNBC KVOA Channel 4 News, Tucson, AZ. June 03, 2009.

Story, D. **M. Kacira**, **C. Kubota**, A. Akoglu. Morphological and Textural Plant Feature Detection Using Machine Vision for Intelligent Plant Health, Growth and Quality Monitoring. International Symposium on High Technology for Greenhouse Systems (GreenSys2009). University of Laval, Quebec, Canada, June 14-19. [Oral Presentation]

Story, D., **M. Kacira**, **C. Kubota** and A. Akoglu. 2009. Autonomous plant health/growth monitoring with machine vision in controlled environments. Presented at the Annual and International ASABE Meeting, Reno, NV, June 24. [Oral presentation]

Kacira, M. 2009. Greenhouse energy management considerations. Greenhouse Crop Production and Engineering Design Short Course, Tucson, AZ, April, 2009. [Oral Presentation]

Kacira, M. 2009. Greenhouse ventilation and cooling. Greenhouse Crop Production and Engineering Design Short Course, Tucson, AZ, April, 2009. [Oral Presentation]

Kubota, C. 2009. Techniques to grow best tasting tomatoes. Greenhouse Crop Production and Engineering Design Short Course, Tucson, AZ, April, 2009. [Oral Presentation]

Kubota, C. 2009. Transplants & Grafting: The first significant step for your success & a business opportunity. Greenhouse Crop Production and Engineering Design Short Course, Tucson, AZ, April, 2009. [Oral Presentation]

Kubota, C. 2009. Production of hydroponic tomatoes rich in flavor and bioactive compounds. New England Vegetable and Fruit Conference, Manchester, NH, December, 2009. [Invited presentation]

Kubota, C. 2009. Review of instrumentation to control the greenhouse environment. New England Vegetable and Fruit Conference, Manchester, NH, December, 2009. [Invited presentation]