Percival Scientific and Iowa State University Collaborate On The Effects of Climate Change on Plant Growth

Project will utilize a fully isolated research facility with eight independent chambers accessed by a robotic rover.

CASE STUDY

PERCIVAL

"It's been really great; it has been a wonderful collaboration. We have worked very closely with the engineers at Percival. They have been very interested in a project that had some very unique challenges, and we have helped each other through it," declares Dr. Stephen Howell, Distinguished Professor and Director of the Plant Sciences Institute at Iowa State University. Howell, formerly Director of the Division of Molecular and Cellular Biosciences at the National Science Foundation in Washington, D.C., was describing Enviratron, a project on which he has collaborated since his return to Iowa State.

BACKGROUND

"What we are really trying to do is test various plants, selected for certain traits, for their ability to respond to different environmental conditions," says Howell, explaining further that with a focus on staple crops such as corn, soybeans and rice as well as bioenergy crops such as switchgrass the project hopes to identify those plant genotypes most able to withstand the coming conditions associated with climate change. "This is a parameter on which no research has been done thus far," he adds. And a good reason exists as to why this work has yet to be done.

THE PROBLEM

Currently plants are tested under differing environmental conditions by planting them at various locations which have differing environmental characteristics and then making observations and taking measurements. This approach is fraught with shortcomings including the inability to isolate the plants from multiple influences other than climate as well as the inability to manipulate the climate to reflect anticipated future conditions.

Current research facilities using plant growth chambers can only provide one climatic model at a time. This limitation inherently reduces the scope of any study to a single variable. They can vary the genotype within a given environment, but cannot vary the environment

as well. And while current facilities improve isolation in juxtaposition to the Iowa outdoors, they still involve removing and transporting plants for sampling which exposes them to uncontrollable elements that in turn introduce uncertainty in the results.

THE SOLUTION

Howell and his collaborators proposed to solve these challenges by creating a fully isolated research facility that contains eight independent chambers that will be accessed by a robotic rover that will do the sampling and testing within the chambers without in anyway altering or contaminating the environment.

The unique rover will operate without remote control in a fully automated manner allowing 24-hour research and employing instrumentation including a holographic camera, hyperspectral sensor, fluorescence detector and a Raman scattering spectrometer. The robot-assisted sensing approach will enable precise location-specific data acquisition, resulting in improved sampling strategies and data quality. "The mountains of high quality data coming out of this project will be staggering," offers Howell of the capacity of the robotics as opposed to the utilization of lab technicians to do the testing and analyzing.

"These chambers had to be specially designed to accommodate the rover which will enter the chamber through an airlock, allow for an equilibration of environment between the airlock and the chamber, and then open to allow the robot access to the plants," said Howell of this multidisciplinary project that is funded by the National Science Foundation and Iowa State University and involves not only Howell and his colleagues but the Department of Agricultural & Biosystems Engineering who are developing the robotics. And of course, Percival-Scientific.

WHY PERCIVAL

"Here at the Roy J Carver Co-Laboratory we have a number of Percival chambers that we have had for many years. They have proven to be very reliable so we were very confident about working with Percival on this project," explains Howell, echoing the opinion of universities and colleges around the country and adding that the opportunity to work with an Iowa based company was a plus as well.

"Designing chambers to be accessible via a robot was just the beginning of the challenges presented to Percival when we began the project, "said Henry Imberti, Senior VP of Engineering for Percival Scientific.

This project necessitated the design of new chamber features, such as an actuated, sliding vestibule door. Not only did the door need to accommodate the unique size of the data acquisition robotics, but also needed to be remotely actuated through the chamber's central control system. Additionally, the door opening required a smooth threshold to accommodate the specialized wheel system on the robotics, while maintaining an adequate seal when closed to ensure environmental conditions inside the experiment space remain undisturbed.

Another area requiring significant development was the optimization of the vestibule environment. The main objective was to retain conditions inside the chamber environment per specifications throughout all operating scenarios. A secondary goal was to minimize system complexity for various reasons including initial cost, energy efficiency, and ease of maintenance. In the end, Percival was able to develop and deploy a design to satisfy both of these design criteria.

Other design challenges included tight control of temperature, humidity, CO2, photoperiod, light irradiance, light quality, air movement, and water potential in the soil. The chambers also had to accommodate a variety of crops such as maize, soybeans, tobacco, rice, switch grass, and low light species as well. And then finally, Percival needed to keep the design costs within the budgetary limitations.

Percival environmental control chambers awaiting placement of the robotic arm. The arm will move between each chamber and access the research materials through the sliding doors on each chamber.

CASE STUDY

THE SPECIFICATIONS

Percival was able to deliver on the design requirements and then some. Design features included:

Growth area: 21.5 ft^2 (2.0 m^2)

Exterior dimensions:
Width: 106" (269 cm
Depth: 84" (213 cm)
Height: 138" (350 cm)

Maximum growing height: 106" (269 cm)

Light intensity: 1720 µmoles/m^2/sec at 36" (91 cm) from the lamps.

Temperature range (Lights on @ 100%): 10°C to 44°C

% relative humidity control range: 40% to 80% from 15°C to 30°C (Lights on @ 100%).

CO2 control range: 100 to 5000 µmol/mol

An Air-flow design optimized through the use of CFD (computational fluid dynamics) software. The design bypass system reduces unwanted leaf movement produced by air currents while the rover is attempting to take measurements

Electrically-actuated lamp canopy that adjusts the height of the lamp bank to be closer to plant canopy for other future light sources such as LED. The lamp design also simplifies any future maintenance or service work the lighting system may require

DALI dimmable lighting allows each ceramic metal halide bulb to dim individually; enhancing the chamber's ability to produce highly uniform light intensity across the growing space

Unique software applications include Percival's propriety WeatherEze. WeatherEze gives Howell and his staff the ability to program the chamber environment to simulate growing conditions from all over the world. Percival's IntellusUltra Control System provides a touchscreen interface as well local and remote data collection and cloud storage.

The Enviratron is now entering the third year of a three to four-year development phase. A facility has been built at the Iowa State Agronomy and Ag Engineering Farm and the eight chambers have been installed. Initial system testing is set to begin February 2017.

WHAT IT ALL MEANS

While melting polar ice caps and rising tides in South Beach are the go-to shots for photojournalists covering climate change, a much less obvious, but no less serious change is occurring in the breadbaskets of the world. Climate change threatens the parameters of regional growing seasons. Research must be done now to identify those genetic traits among our food crops that will best prepare those crops to endure the gradual changes in environment that are already anticipated to occur. The Enviratron will permit scientists to incrementally alter critical variables in keeping with projected changes and will better prepare the agricultural community from the research scientist to the farmer in the field to continue to provide the products that sustain the world's population, a task of the highest priority, and one to which Percival-Scientific is honored to contribute.

For more information, please visit www.percival-scientific.com, call 1.800.695.2743 or email info@percival-scientific.com