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

CASE STUDY

When researchers from the Plant Sciences Institute at Iowa State University asked Percival Scientific to collaborate on a first-of-its-kind research facility with customized chambers that could be accessed by a robotic rover, the Percival engineering team jumped at the chance.

The multidisciplinary project, called Enviratron, was initially funded by the National Science Foundation and led by Dr. Stephen Howell, Distinguished Professor and Director of the Plant Sciences Institute and former Director of the Division of Molecular and Cellular Biosciences at the National Science Foundation in Washington, D.C. "It has been a wonderful collaboration," says Howell. "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."

Testing Plants Against Climate Change

"What we are really trying to do is test various plants, selected for certain traits, for their ability to respond to different environmental conditions," explains Howell. The project focuses on staple crops such as corn, soybeans and rice, as well as bioenergy crops like switch grass, to identify plant genotypes most able to withstand climate changes. "This is a parameter on which no research has been done thus far," he adds.

The Obstacles of Climate-Based Research

Up to this point, testing the impact of climate changes on plants typically has been done by planting them in various locations with different environmental conditions 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 reduces the scope of any study to a single variable: the genotype of the plants. And while current facilities provide consistent environmental conditions as compared to outdoors, they still require removing and transporting plants for sampling, which exposes them to uncontrollable elements that introduce uncertainty in the research results.

Chambers Designed for Automated Testing

Howell and his team worked with Percival to solve these challenges by creating a fully isolated research facility. It contains eight independent chambers which are accessed by a robotic rover that samples and tests plants within the chambers without altering or contaminating the environment. It's the first facility to conduct automated phenotyping of plants under a variety of environmental conditions in a single experiment.

The rover, which was developed with the help of the Department of Agricultural and Biosystems Engineering, is fully automated, allowing 24-hour research testing using a holographic camera, hyper-spectral sensor, fluorescence detector and a Raman scattering spectrometer. The rover collects precise location-specific data, resulting in improved sampling strategies and data quality. "The mountains of high-quality data coming out of this project will be staggering," says Howell, when comparing the accuracy, consistency and productive time of automated testing to that of lab technicians.

Percival specially designed the chambers to accommodate the rover, which enters the chamber through an airlock. After the environment has been equilibrated between the airlock and the chamber, a divider raises to allow the robot access to the plants.

These are not your standard chambers," says Steve Whitham, Iowa State University Professor, Plant Pathology and Microbiology. "They've been designed from the ground up specifically for the Enviratron project."

Percival Takes On the Challenges

"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. He adds 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 rover, but it 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 rover while maintaining an adequate seal when closed to ensure environmental conditions inside the experiment space remained undisturbed.

Another aspect requiring significant development was the optimization of the vestibule environment. The main objective was to retain environmental conditions inside the chamber 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 criteria.

Other design challenges included tight control of temperature, humidity, CO_2, photo period, 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. Finally, Percival needed to keep the design costs within budget.

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%)
- **CO_2 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 the plant canopy for other future light sources such as LEDs. 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, which gives Howell and his team 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.

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

The Global Impact

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. Iowa State University and Percival Scientific support urgently needed research to identify those genetic traits among our food crops that will withstand the gradual changes in environment that are already occurring. Enviratron will permit scientists to incrementally alter critical variables in keeping with projected changes. It will help prepare the agricultural community, from the research scientist to the farmer in the field, to continue providing the products that sustain the world's population, a task of the highest priority.