Controlled Environment Use and Technology

This project developed new guidelines and environmental control technologies, making sure that growing and studying plants in greenhouses, growth chambers, and other controlled environments is easy, precise, cost-effective, and produces reliable experimental data and high quality crops.

Who cares and why?

Agricultural issues related to crop production, the environment, and dietary health impact the entire nation's well-being. To find solutions to these issues, research in a "controlled environment" is often required. Research conducted in a carefully controlled setting provides sound scientific data that can be used to support agricultural policies and practices. Controlled environments are also increasingly used to sustainably grow commercial crops and garden, orchard, and nursery plants. Greenhouses and other controlled environments are becoming more important for growing food in areas where traditional farming is impossible or insufficient due to shorter growing seasons, extreme temperatures, limited precipitation, and/or poor sunlight levels. With so many important uses of plants for food, feed, fiber, and pharmaceuticals, greenhouse plant production has become a multi-million dollar industry; however, controlled environments are expensive to operate, depend heavily on sophisticated technologies, and require careful management. New environmental control technologies are needed to make controlled environments easier and cheaper to for plant growers and researchers to use.

The greenhouse at Chena Hot Springs in Alaska (top, photo by James Keller) is heated entirely using geothermal energy and has been able to maintain a temperature of 78°F even when outside temperatures dropped to -56°F. This facility provides a steady supply of fresh produce, including tomatoes, green beans, peppers, cucumbers, greens, and herbs (bottom, photo by Scott McMurren), helping the community achieve greater independence in food production.

What has the project done so far?

NCERA-101 has brought together a mix of researchers, plant growers, engineers, and greenhouse manufacturers who have led the development of new ideas and technologies for research and agriculture in controlled environments. Project members have developed new greenhouses, including one in Louisiana that can withstand Category 4 hurricanes, a facility at the South Pole Station that produces fresh vegetables, and greenhouses in Alaska that use geothermal energy. Partnering with NASA and the Kennedy Space Center, NCERA-101 researchers have also designed technology for growing crops in the International Space Station. NCERA-101 members have developed better disease, weed, and pest control tactics, improved fertilization systems, and energy-saving irrigation systems, light fixtures, and temperature settings. The group has installed more precise sensors and online programs for operating controlled environments remotely and has developed software (Virtual Grower) which helps growers plan ahead and make good decisions. The group has also standardized ways of collecting and reporting data from controlled environments, so that scientists can more easily compare and apply findings on a broad scale. The group has continuously held workshops, led tours, provided consultations, and created educational materials, such as the web-based Knowledge Center for Water, Nutrient and Plant Health Management. The group has also continued to work with industry and government partners to license new technologies and make sure that it can be quickly put into practice.

Impact Statements

Built international partnerships between academia and industry that coordinated the exchange of information and resources, speeding up technological advances.

Updated greenhouse designs and management practices, saving average-sized greenhouse businesses about $20,000 each year.

Helped growers produce high-quality crops year-round by designing greenhouses that meet specific needs related to local climate and weather, available energy sources, and cultural practices. These greenhouses have provided consumers with a wider range of fresh, locally-grown food choices and growers have earned higher prices for "out of season" crops. Overall, adapting greenhouses for a variety of communities and uses has made the greenhouse industry economically and socially sustainable.

Discovered pest, disease, and weed control methods that have prevented plant losses and food safety issues, earning consumer acceptance of food produced in controlled environments.

Made controlled environments more cost-efficient and environmentally friendly by developing computer models, software, sensors, automated controllers, and energy audit checklists that have reduced water and fertilizer use, saved labor and money, and maximized crop growth and quality. Growers who used these tools have had energy savings of 5-30% without losses in productivity or quality.

Addressed agricultural issues related to the environment, food production, dietary health, and climate change by advancing technology for studying and growing more nutritious, higher-yielding, drought-tolerant, and pest-resistant crops as well as plants that can be used as alternatives to fossil fuels.

Scientists have designed growth chambers so that plants can be grown on board space craft during long missions, offering astronauts a steadier, more nutritious diet. Researchers are also developing plans and technologies for more complex, small-scale food production facilities in space, like the artist's rendering of an astronaut in a space greenhouse shown above. Image courtesy of NASA.

What research is needed?

Scientists need to develop more precise and reliable ways of measuring and reporting conditions in controlled environments. Future controlled environment designs must have improved energy efficiency, be adapted for specific locations, and endure future changes in climate and environmental factors. Scientists must ensure that an international network is established so that advances in controlled environment technology can be shared rapidly and effectively.

Want to know more?

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Project website:
http://www.controlledenvironments.org/

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