Commercial Greenhouse Production

NE-1035 (2008-2013)

Greenhouse Industry Needs Better Equipment in order to Grow

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In the U.S., the greenhouse and nursery industry continues to grow, swelling to a value of over $16 billion in recent years. Greenhouses, in particular, allow growers to fine-tune growing conditions, making it possible to grow high-maintenance plants, grow in areas with harsh environmental conditions (such as poor soil, low light, and temperature extremes), and/or grow year-round. By manipulating the growing environment, it is also possible to stimulate the production of plant compounds related to nutritional, pharmaceutical, and aesthetic qualities.

Greenhouses present unique management challenges. They require equipment for heating, ventilating, and delivering water, nutrients, pesticides, and herbicides as well as a range of manual and computerized controls, sensors, and timers for monitoring conditions. As greenhouse operators face rising energy costs, they need technology and guidance to reduce energy consumption and take advantage of alternative fuel sources like biomass and solar.

Multistate Research Project Provides Tools & Insights for Operating Greenhouses

Multistate Research Project NE-1035 has brought together plant scientists and engineers who have shared their expertise, research facilities, funding, and other resources, enabling innovative research that has improved the viability of commercial greenhouse agriculture. Here are some of the impacts of NE-1035's work over the past five years:

NE-1035 studies have **shed light on variations in greenhouse conditions that affect plant growth and quality.** For example:

- pH control increased average lettuce head weight from 119 grams to 162 grams.
- Strategic use of supplemental light enhanced nutritional value and growth of baby leaf lettuce.
- Certain conditions increased genetic expression of valuable chemicals in tobacco.
- Poinsettia and petunia grown in larger containers attained greater biomass.

Improved tools, sensors, and control systems for water, light, and temperature have **made it easier for greenhouse operators to manage their facilities with precision.** Newly developed low-cost tools and multi-sensor platforms have not only **improved monitoring capabilities**, but also cut costs for operators. For example, researchers:

- Developed a multi-camera machine capable of monitoring crop growth and health in real time. The system detected lettuce tipburn, water stress, and calcium deficiency prior to detection by human vision.
- Designed instrumentation that can be used to observe crop problems over the Internet, making remote monitoring possible.
- Developed a new design for insect scouting that uses a suction device and yellow sticky card mounted on a traveling boom that is more reliable than the conventional scouting method using a stationary sticky card.

Improved greenhouses have **made it possible for growers to cost-effectively maintain desirable characteristics in their crops**, especially those with health-beneficial compounds and biopharmaceutical properties.

Better quality produce has the p**otential to significantly increase economic returns for greenhouse operations as higher nutrient content could be used to promote the sale of food grown in local greenhouses.**

Ideally, the nutrient solution (water and fertilizer mixture) used to irrigate greenhouse plants is recycled and used in the next irrigation cycle instead of going to waste or being dumped into the surrounding environment; however, recycling nutrient solution poses several challenges: a large container to store used nutrient solution for the next irrigation cycle; unwanted residues that can accumulate over time; and potential for disease organisms to spread rapidly. Without improved recycling technology, growers may be forced to use expensive systems to treat and dispose of wastewater in addition to shouldering the cost of supplying fresh nutrient solution each cycle. Photo by Advanced Irrigation Systems.

Improvements to irrigation and ventilation have **reduced incidence of disease in greenhouses, protecting crop quality.** For example:

- Plants grown using a Partial Saturation Ebb and Flow irrigation system (PSEF) used 20% to 30% less water and fertilizer and had

enhanced quality characteristics. PSEF also greatly reduced the spread of disease.
- A biopesticide made from extract of giant knotweed significantly reduced downy mildew infection of coleus leaves.
- New protocols for filtering and sterilizing nutrient solution prevent spread of pathogens or toxins when it is recirculated.

NE-1035 also discovered **alternative energy sources, energy conservation practices**, and **more efficient watering and fertilization methods** that **reduce operating costs while still maintaining crop quality**.
- Fertilizer guidelines reduced harmful salt accumulation for bedding plant species growing in sub-irrigation.
- Variable pressure and vent control strategy reduced water use by 36% and consumed 30% less electric energy than fixed pressure and vent control.
- Energy conservation strategies saved New Jersey growers between 5% and 30% on their energy costs.
- A 250-kilowatt landfill gas-fired microturbine generated both electricity and heat for a one-acre greenhouse facility. The microturbine had an overall conversion efficiency 20% to 30% higher compared to separate heating and power generating systems.
- Use of LED lighting in a plant growth chamber reduced energy consumption for lighting by 85% and overall electrical consumption by 40%.
- Guidelines for bedding plant species growing in sub-irrigation reduced fertilizer concentrations by 30% to 50% compared with overhead irrigation.
- An applied research and outreach program gave participating growers an average economic gain of $9,000, with a cumulative economic gain of $125,500.

Improvements in energy efficiency have also **reduced environmental impacts**.
- Recirculation technology reduced the amount of fertilizer used to grow tomato crops, avoiding the discharge of water and fertilizer to aquifers or to treatments facilities.
- A newly designed aquaponics greenhouse provides an environmentally friendly way to produce fish and vegetables simultaneously. The greenhouse uses fish effluent as a sustainable and efficient nutrient source for intensive vegetable production, while the plants serve as a filtration system.
- Nitrogen and phosphorus leaching were reduced by more than five-fold by using controlled release fertilize for fall Poinsettia production.

NE-1035 outreach has **made it easier to choose and use equipment for managing and monitoring greenhouses**.

New designs and management procedures, along with **better training and knowledge sharing**, have **improved the health and safety of greenhouse operators.**
- Fluopicolide is very effective against water molds, and alternating this fungicide with current industry standards, which are known carcinogens, would reduce the amount of carcinogens greenhouse workers are exposed to by 50%.
- A series of workshops and student internships trained potential greenhouse managers and workers.

Together, these improvements have made commercial greenhouses a viable and important segment of agricultural production in the U.S., contributing to the local availability, sustainability, and security of the food supply. With better technology and guidance available, there has been increased adoption of greenhouses, high tunnels, hydroponics, and other controlled environment agriculture facilities amongst growers in several states.

Want to know more?

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Administrative Advisor:
Edward N. Ashworth (edward.ashworth@umit.maine.edu)

Participating Institutions:
University of Alaska, Fairbanks
University of Arizona
University of Connecticut, Storrs; New Haven
Cornell University
University of Illinois
University of Kentucky
University of Maine
Michigan State University
University of Nebraska
Ohio State University
Pennsylvania Cooperative Extension
Rutgers University

This Impact Summary was compiled and designed by Sara Delheimer.

Properly designed ventilation systems are essential for controlling air temperature, humidity, and concentrations of gases in the greenhouse environment. Advantages such as lower energy consumption, cost, maintenance, and noise have spurred a major shift back to natural ventilation; however, appropriate tools and strategies are needed to ensure uniformity, energy efficiency, and production quality among naturally ventilated greenhouses. Photo by Dwight Sipler, CC License 2.0, Flickr.