Editor's Note: This is the first in a series of articles highlighting research by the USDA-ARS Greenhouse Production Research Group.

Research is Our Middle Name

THE USDA'S AGRICULTURAL RESEARCH SERVICE IS COMPRISED OF MORE THAN 90 RESEARCH LOCATIONS, BUT THE GROUP IN TOLEDO, OHIO, IS THE ONLY ONE FOCUSED ON GREENHOUSE AND PROTECTED HORTICULTURE CROP PRODUCTION.

By Jennifer Boldt, James Atland, Jim Locke and Charles Krause

As the title of this article implies, 'research' is literally, and figuratively, our middle name. We are the Greenhouse Production Research Group (GPRG), a part of the USDA's Agricultural Research Service (ARS). The Agriculture Research Service is the in-house scientific research agency for the USDA and is comprised of more than 90 research locations and 2,100 scientists. Our goal is to find and develop solutions that benefit farmers, growers and consumers. Our group in Toledo is unique in that we are the only team within ARS to focus on greenhouse and protected horticulture crop production.

The GPRG was initiated with new congressional funding in 2001 and is physically located in Toledo, Ohio. We are a worksite administered by the Application Technology Research Unit (ATRU), located in Wooster, Ohio, at the Ohio State University's Ohio Agricultural Research and Development Center. Altogether, the ATRU has eight research scientists focused on improving production and management practices, reducing disease and insect incidence, and improving the quality of floriculture and nursery crops. The ATRU has three major research focus areas:

1) The Agricultural Engineering Research Group includes Dr. Heping Zhu and Dr. Rich Derksen. They evaluate the spray distribution patterns of greenhouse sprayers and nozzles, study the effects of spray droplet size on pesticide efficacy and develop "smart" sprayers that, for example, can go through an orchard and only spray when its sensors indicate there are trees and foliage present. Their goal is to improve pesticide application methods which reduce unnecessary pesticide use (i.e. to non-targeted, non-production areas of a greenhouse or field).

The Greenhouse Production Research Group (Back row: James Atland, Wendy Zellner, Charles Krause; Middle row: Madison Roze, Jim Locke, Adam Hall; Front row: Mona-Lisa Banks, Jennifer Boldt, Doug Sturtz, Sujin Kim)

2) The Horticultural Insects Research Group is comprised of Drs. Michael Reding and Christopher Ranger. Their research targets key pests of ornamental crops, particularly wood-boring ambrosia beetles. Research efforts focus on improving monitoring and detection strategies in nurseries, predicting seasonal flight activity, determining what factors cause nursery trees to become susceptible to beetle attacks, identifying attractants and repellents and evaluating the effectiveness of conventional and reduced-risk insecticides.

3) The GPRG's mission is to conduct research projects which will help you, the growers, produce high-quality greenhouse crops while using less inputs (nutrients, chemicals, water and/or energy).

Who are we?

The GPRG is currently comprised of four research scientists, one post-doc, three technicians and one IT specialist. Our main research laboratory is located on the main campus of the University of Toledo, in northwest Ohio. Here, we have laboratories, a rooftop greenhouse, and growth chambers. We also lease a second greenhouse complex with multiple bays and production environments at the Toledo Botanical Garden.

Current Research

With a broad set of backgrounds and expertise among our research scientists, we are able to diversify into many different areas of greenhouse production. We are currently conducting studies to look at the role of silicon in reducing or delaying the effects of abiotic (environmental) and biotic (pathogen) stress, evaluate the potential of new substrate amendments to provide nutrients or adjust pH, improve control of weeds in container production, develop energy-efficient greenhouse production methods and continue to develop our decision-support software called Virtual Grower. Here is a quick overview of some of our current projects (more info can be found on our website, www.greenhousescience.net).

Silicon

Do plants need silicon? Well, yes and no. Plants can germinate, grow, flower and set seed in its absence, but they often grow better when it is supplied. Currently, it is considered a beneficial element. While silicon is abundant in field soils, very little is found in soilless media or hydroponic solutions. The plant-available form is silicic acid. A few years ago, we trialed a number of greenhouse crops in hydroponics to evaluate how much silicon plants were able to accumulate in their leaves. Now, we are looking at how plants regulate the uptake of silicon into their roots and what internal and external signals trigger its movement into leaves. Leaves are an important final destination for silicon because they are where many pathogens and insects attack, and they are where light, temperature and nutrient stresses often occur.

So, how does silicon help? We know silicon can reduce or delay the effects of various stresses. Researchers at Cornell showed that it can help poinsettias better withstand drought conditions. In our lab, we have shown that silicon helps mitigate copper toxicity, delay the onset of powdery mildew in zinnia and delay aphid development. In upcoming experiments, we plan to see if silicon can also help protect against other heavy metal toxicities, heat stress, bacterial pathogens and Pythium.

One current approach to supply silicon to plants is as a liquid supplement, using potassium silicate. But, we were curious to see if any amendments, mixed in to soilless media prior to transplant, would provide plant-available silicon. We found rice hulls, some forms of biochar, steel slag and Miscanthus all provided supplemental silicon to container-grown plants.

Substrate Amendments

Another research focus of ours is to examine the various properties of soilless substrate amendments and see what nutritional, chemical and physical benefits they can provide in container production. Of particular interest is whether any of these amendments can provide nutrients, like phosphorus or potassium, or adjust the media pH. Next month, we will introduce you to our research with biochar and discuss its potential utility in substrates.

Cation exchange capacity (CEC), the capacity of a substrate to hold on to positively charged ions (e.g., ammonium, phosphate, potassium, calcium, magnesium, etc.), varies with soil amendment, particle size, source/supplier, and how CEC is reported. Dr. Altland recently looked at the CEC of four different loblolly pine bark sources. Here are some major points of interest from his study:

- CEC reported on the basis of volume (meq/L) rather than mass (meq/100 g) is preferable when discussing container substrates that have wide ranging bulk densities and fixed container volume.
- Finer-sized pine bark particles have a greater CEC than coarse bark chips.
- Amending pine bark with limestone (from 0 to 16 lb/yd^3) does not significantly affect CEC.
- Amending pine bark with differing percentages of peatmoss does not significantly alter volumetric CEC values.

Controlling Weeds in Containerized Production

Since few chemical herbicides are labeled for indoor use, and hand weeding is laborious and time consuming, we are interested in developing effective, non-chemical techniques for controlling weed germination and spread in containerized production. We are focusing on liverwort, bittercress, oxalis, willowherb and woodsorrel. We plan to improve our understanding of their life cycles — what triggers germination, what affects growth and flowering, and what affects seed set? We hope by understanding what stimulates their growth and development, we can develop control strategies that are targeted at disrupting their growth, thus reducing their prevalence in containers. Be on the lookout; we'll have an entire article devoted to weed control in two months.

Optimizing the Greenhouse Environment

In the greenhouse business, we are often at the mercy of Mother Nature. If it's cold outside, we heat our crops; if it's cloudy, we turn on supplemental lights; if it's sunny, we close the shade curtains. But what are the optimal conditions for plant growth? And how big of an effect does a short-term stress have on long-term growth and development? We are measuring the photosynthetic rate of many commonly grown greenhouse crops across a range of temperature, light and CO_2 conditions. From this, we will be able to determine at what conditions photosynthesis is zero (i.e. the point below which a plant is consuming more food energy than it is creating and begins to starve itself), and at what point adding additional light or CO_2 will no longer provide any additional benefit. We can use this information to classify crops into response groups that can be grown together. In addition, we are looking at how quickly it takes a plant to recover from a short-term stress, albeit high light or high or low temperature, and how regular, intermittent stress events can affect the long-term quality of crops and scheduling. Which leads us to...

Virtual Grower

Virtual Grower is a decision-support software program that allows users to custom build a virtual greenhouse, schedule crops, predict energy use and predict plant growth. It was originally designed by Dr. Jonathan Frantz and initially released to the public in 2006. Since then, it has been downloaded more than 20,000 times by people in over 80 countries! Over the years, Virtual Grower has been expanded and updated; it is now compatible with both PCs and Macs and available in English, Spanish and French. In May, we welcomed aboard a new software designer, so we are gearing up to work on the next version of Virtual Grower. We will be incorporating a lot of our plant growth data into the next edition. If you have any suggestions, we welcome your feedback.

Sneak Peek

Over the next few months, we will share our latest findings and insights pertaining to biochar, containerized weed control and optimization of the greenhouse environment, plus a sneak peek on updates to Virtual Grower. We look forward to sharing our latest research results with you! g

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