1-2012

Comparing Light-Conversion Efficiency of Plants and Manmade Solar Cells

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When it comes to using light energy, how do manmade photo cells compare to plants' photosynthesis? An Agricultural Research Service scientist participated in a study comparing how efficiently plants and photovoltaic cells convert sunlight into energy. The study, published in *Science,* could help researchers improve plant photosynthesis—a critical first link in the global supply chain for food, feed, fiber, and bioenergy production.

Comparing the two systems is a challenge. Although both processes harvest energy from sunlight, they use that energy in different ways. Plants convert the sun's energy into chemical energy, whereas solar cells produce electricity.

Scientists know that plants are not as efficient as manmade solar cells at converting light into energy, according to research leader Donald Ort in the ARS Global Change and Photosynthesis Research Unit in Urbana, Illinois. "But now we have a way of comparing the two systems more accurately," he said. The study identified specific redesigns that hold excellent promise for improving efficiency.

To facilitate direct comparison between photosynthetic and solar cell systems, the researchers set a uniform basis for the comparison and examined the major factors that define the efficiencies of both processes—first considering current technology, then looking forward to possible strategies for improvements. In all cases, the research team considered the efficiency of harvesting the entire solar spectrum as a basis for comparison. Additionally, the researchers compared plants to solar cell arrays that also store energy in chemical bonds. Calculations were applied to a solar cell array that was coupled to an electrolyzer that used electricity from the array to split water into hydrogen and oxygen. The free energy needed to split water is essentially the same as that needed for photosynthesis or a solar cell, so the comparison is on a level playing field.

Using this type of calculation, the annual averaged efficiency of solar cell-driven electrolysis is about 10 percent. Solar energy conversion efficiencies for crop plants are about 1 percent, which illustrates the significant potential to improve the efficiency of the natural system.

"While, in the context of our efficiency analysis, solar cells have a clear advantage compared to photosynthesis, there is a need to apply both in the service of sustainable energy conversion for the future," says Ort. "Our ultimate goal is to design food and biofuel crops that use sunlight energy more efficiently and are thus higher yielding. This energy-efficiency analysis between plant photosynthesis and solar cells will lay the groundwork for improving the efficiency of plant photosynthesis in agriculture for improved yield."

In addition to ARS, numerous other organizations and universities, both in the United States and abroad, participated in various aspects of this research.—By **Sharon Durham,** ARS.

This research is part of Plant Genetic Resources, Genomics, and Genetic Improvement, an ARS national program (#301) described at www.nps.ars.usda.gov.

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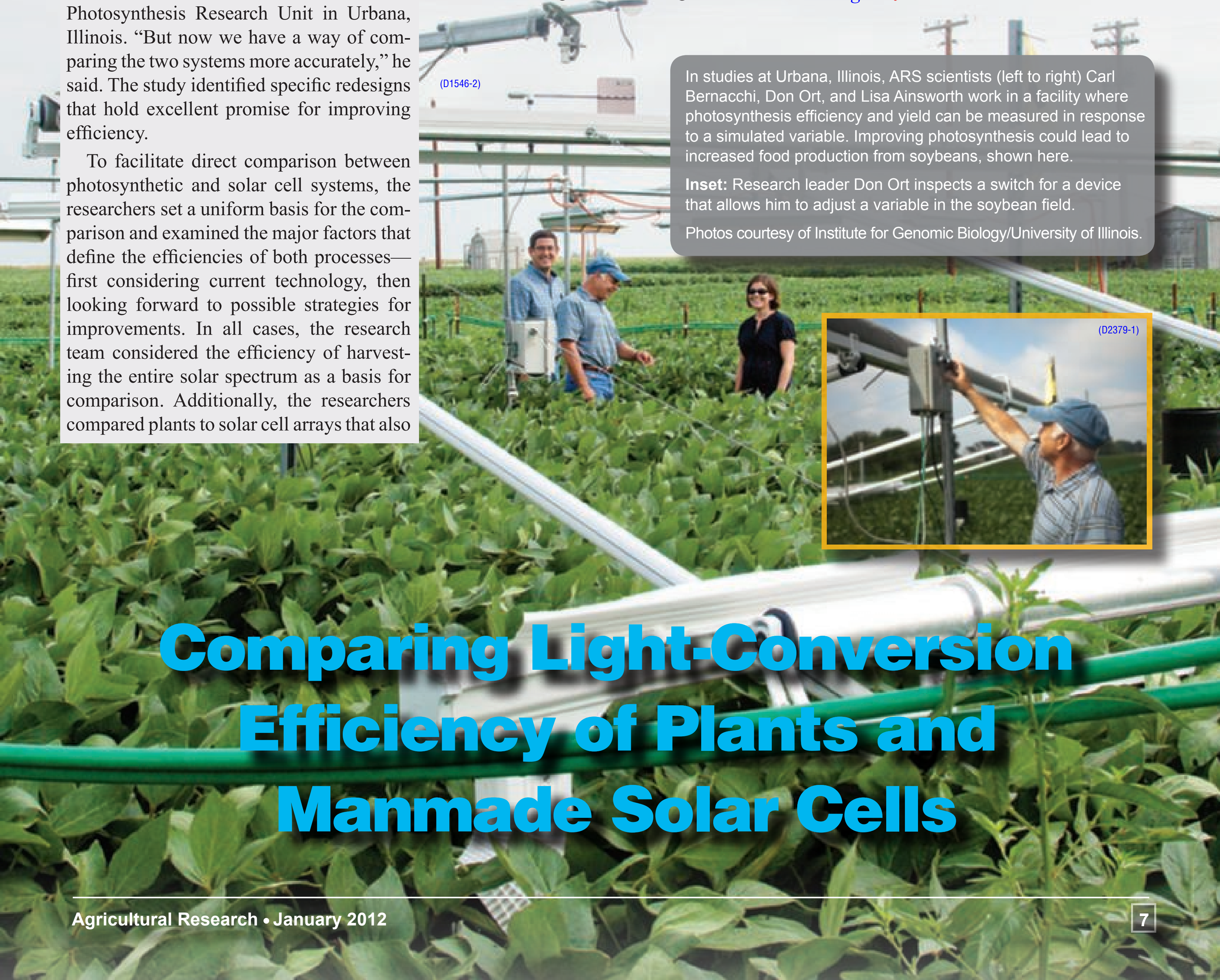

In studies at Urbana, Illinois, ARS scientists (left to right) Carl Bernacchi, Don Ort, and Lisa Ainsworth work in a facility where photosynthesis efficiency and yield can be measured in response to a simulated variable. Improving photosynthesis could lead to increased food production from soybeans, shown here.

Inset: Research leader Don Ort inspects a switch for a device that allows him to adjust a variable in the soybean field.

Photos courtesy of Institute for Genomic Biology/University of Illinois.